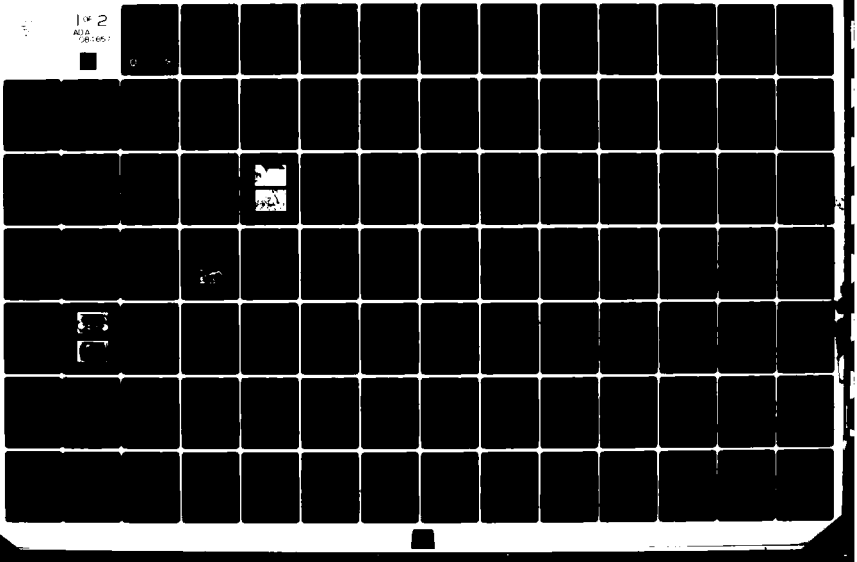
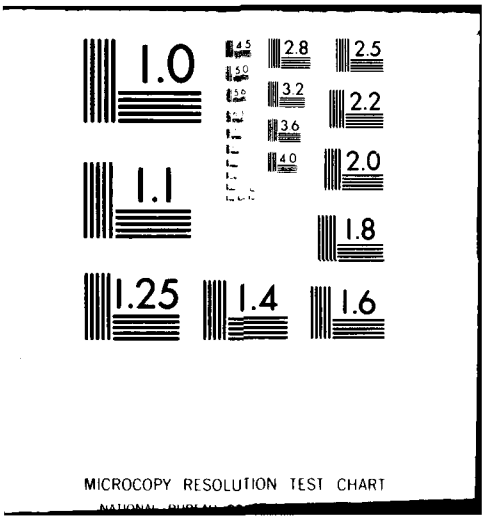
AD-A084 657 ATLANTIC RESEARCH CORP ALEXANDRIA VA F/G 13/2
PILOT-SCALE EVALUATION OF THE TREATABILITY OF RDX/HMX SITE 'X' --ETC(U)
APR 80 J F KITCHENS, R G HYDE, D A PRICE DAEA18-69-A-0223
UNCLASSIFIED ARC-49-5766-1 ARCSL-CR-80028 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART

LEVEL III

(12) B.S.

AD-E410 256

ADA084657

CHEMICAL SYSTEMS LABORATORY CONTRACTOR REPORT

ARCSL-CR-80028

PILOT-SCALE EVALUATION OF THE TREATABILITY OF RDX/HMX SITE "X" FACILITY WASTEWATERS

Final Report

by

Judith F. Kitchens
Raymond G. Hyde
Debra A. Price
Kenneth S. Hyde
William E. Jones, III
William M. Scott
Randall S. Wentsel

MAY 2 3 1980

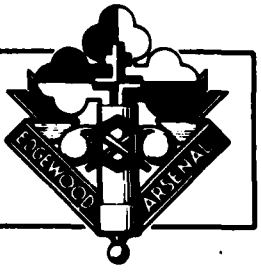
A

April 1980

ATLANTIC RESEARCH CORPORATION
5390 Cherokee Avenue
Alexandria, Virginia 22314

Contract No. DAE18-69-A-0223

DEPARTMENT OF THE ARMY
Headquarters, Edgewood Arsenal
Aberdeen Proving Ground, Maryland 21010



FILE COPY

Approved for public release; distribution unlimited.

80 5 2 012

Disclaimer

The views, opinions and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

CONTRACT:
Per CSL Proj Officer,
Dr John Thomas, AV 584-3133
Contract no. is DAEA 18-.

(((K/SAIC/TCD
9 May 80

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARCSL-CR-80028 ✓
2. GOVT ACCESSION NO.: AD-A084 657
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): PILOT-SCALE EVALUATION OF THE TREATABILITY OF RDX/HMX SITE "X" FACILITY WASTEWATERS
5. TYPE OF REPORT & PERIOD COVERED: Final Report, April 1979 - December 1979
6. PERFORMING ORG. REPORT NUMBER: 49-5766-1

7. AUTHOR(s): Judith F. Kitchens, Kenneth S. Hyde, Randall S. Wentsel, Raymond G. Hyde, William E. Jones, III, Debra A. Price, William M. Scott
8. CONTRACT OR GRANT NUMBER(s): DAAA18-69-A-0223

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Atlantic Research Corporation ✓, 5390 Cherokee Avenue, Alexandira, Virginia 22314
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Project No. MMT5772528, RDX-HMX Expansion

11. CONTROLLING OFFICE NAME AND ADDRESS: DCAS Region - Philadelphia, P.O. Box 7730, Philadelphia, Pennsylvania 19101
12. REPORT DATE: April 1980
13. NUMBER OF PAGES: 185

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Chemical System Laboratory, US Army Armament R&D Command, Aberdeen Proving Ground, Maryland 21010
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: NA

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Supporting Agency- US Army Munitions Production Base Modernization Agency
Base Modernization and Expansion, Dover, New Jersey
Contract Project Officer: Dr. John C. Thomas (DRDAR-CLN-TT, 671-3133)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

TNT	Formic acid	Wastewater treatment
HMX	Formaldehyde	Rotating biological contactors
RDX	Cyclohexanone	RDX/HMX manufacturing wastewater
Acetone	Biodegradation	
Acetic acid	Pollution abatement	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In this program, the feasibility of treating the wastewaters from the Site "X" RDX/HMX manufacture facilities in aerobic rotating biological contactors (RBC) was evaluated. These wastewaters contain explosives such as RDX, HMX, and TNT; formaldehyde; formic acid; acetic acid; and solvents such as cyclohexanone and acetone. A pilot scale RBC was used in this investigation. The results from the pilot scale evaluation indicate that 95-100% soluble BOD removal can be achieved and maintained at soluble BOD loading rates of <2.5 lb/1000 sq ft/day.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

045 550

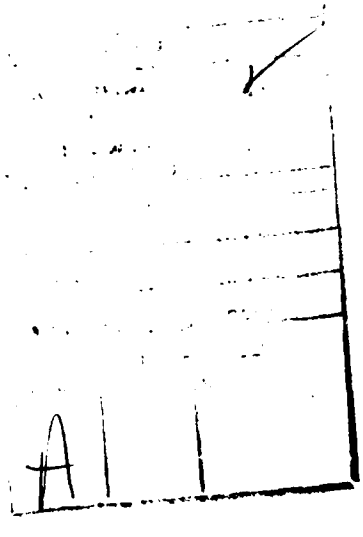
PRECEDING PAGE BLANK-NOT FILMED

PREFACE

The work described in this document was carried out under contract DAE18-69-A-0223, from April 1979 to December 1979. This is an ARRADCOM contract.

Reproduction of this document in whole or in part is prohibited except with permission of Commander/Director, Chemical Systems Laboratory, Attn: DRDAR-CLJ-R, Aberdeen Proving Ground, MD 21010. However Defense Technical Information Center and the National Technical Information Service are permitted to reproduce the document for U.S. Government purposes.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.



PRECEDING PAGE BLANK-NOT FILMED

SUMMARY

The Army is currently in the process of designing a new facility for the manufacture of the explosives, RDX and HMX. In addition to the explosives manufacturing lines, this facility, RDX/HMX Site "X", will contain all the ancillary processes necessary for production of final products. The ammonia recovery, acetic acid concentration, acetic anhydride manufacture, blending operations, etc. The wastewaters generated by the site "X" facility will contain a variety of contaminants, including formaldehyde, formic and acetic acids, solvents and other byproducts. The only potentially feasible treatment for this mixed wastewater was biological treatment. However, it was not known if microorganisms could survive in the high concentrations of formaldehyde present in the wastewaters or if the wastewater components could be efficiently biodegraded. This report presents the results of a nine-month pilot scale evaluation of the treatability of Site "X" wastewaters.

The pilot study was conducted on two wastewater flows and concentrations:

- "A": dry weather stream with a flow of 1,544,500 gal/day and an average soluble BOD concentration of 1187 ppm
- "B": dry weather stream minus 546,200 gal/day of heat exchange condensate or a flow of 998,300 gal/day and an average soluble BOD concentration of 1840 ppm

Pilot plant data showed that 95-100% soluble BOD reduction can be achieved and maintained on either the "A" or "B" stream. The maximum loading that can be achieved is ∿2.5 lb soluble BOD/1000 ft^2/day. At this loading rate, the system is dissolved oxygen limited. Loadings at 2.0 to 2.2 lb soluble BOD/1000 sq. ft./day are more realistic. Based on the data obtained from the pilot operations, preliminary design criteria for the full-scale site "X" wastewater treatment facility were formulated.

PRECEDING PAGE BLANK-NOT FILMED

TABLE OF CONTENTS

Table of Contents (cont.)

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

A. Background

The U.S. Army is currently in the process of designing a new facility for manufacture of RDX and HMX. This facility, RDX/HMX Site "X", will incorporate not only the explosive production but all the ancillary processes necessary to manufacture and blend these explosives. These ancillary processes will include nitric acid plants, acetic acid dehydration, acetic anhydride production, explosives formulation and blending operations and wastewater treatment facilities. Three sites have been selected as potential locations for the "X" facility. These sites are:

- Milan, Tennessee
- McAlister, Oklahoma
- Newport, Indiana

One of the considerations in final selection of the "X" facility site is the impact that the discharges from the facility will have on the environment. It is anticipated that the "X" facility discharges from production operations will be between 998,300 and 1,544,500 gallons per day with the two initial lines in full operation. However, eventually two additional lines (four total) may be built at this facility. The wastewater treatment plant designed for the "X" facility must be capable of treating these effluents so that discharges will comply with existing and future effluent limitations imposed by the state and EPA.

At the existing Army RDX/HMX manufacturing facility, Holston Army Ammunition Plant (HAAP), biological treatment of wastewaters utilizes well established technologies, *i.e.* fixed-film reactors, trickling filters and activated sludge. However, since the design of HAAP wastewater treatment plant, advances in wastewater treatment technology directed consideration of the rotating biological contactor (RBC) as replacement technology. Other recent experimental studies have identified the RBC as a highly cost effective method for treatment of certain munitions plant wastewaters. Preliminary cost studies indicated that the RBC would be preferred technology for treatment of "X" facility wastewaters provided technical feasibility could be demonstrated.

The expected quantity and quality of the wastewaters from the "X" facility are shown in Table 1. These wastewaters contain the same pollutants as found at HAAP. However, the quantity and quality of the projected "X" facility wastewaters are significantly different from that found at HAAP. The expected volumes of wastewater are less than at HAAP due to new manufacturing methods coupled with extensive at-source pollution control. Because the wastewater volume has been substantially reduced, the concentrations of many of the individual components in the "X" facility wastewater exceed that in evidence at HAAP. In particular, high concentrations of formaldehyde appeared to be a potential problem since this chemical is inhibitory to many microorganisms.

Table 1. Quantities of Contaminants in Raw Industrial Water[a] (ARRADCOM, 1979)

Source	Process Lines 1 & 2	Process Acid Conc.	Process Wash Down AcAn Plant	Process Wash Down Lines 1 & 2	Process Wash Down Nitric Acid Plant	Process Wash Down AcAn Plant	Process Wash Down Acetic Acid Conc.	Heat Exch. Conc.	Water Treatment	Blowdown Boiler	Blowdown Cool Twr	Total Ion Exchange	Total Dry Weather Wastewater lb/day	Total Dry Weather Wastewater Mg/l	Contaminated Storm Run Off Coal Stor	Contaminated Storm Run Off Nitric Acid Plant	Contaminated Storm Run Off Acetic Acid Plant	Contaminated Storm Run Off Acetic Acid Rec.	Total Wet Weather Wastewater lb/day	Total Wet Weather Wastewater Mg/l
TOTAL FLOW gal/day[b]	63,500	108,600	7,200	149,000	3,000	3,000	3,000	546,200	204,200	31,700	369,400	55,600	1,544,500		544,900	83,000	213,300	101,800	2,487,500	
Contaminants lb/day																				
pH	7-8	4-6	6-75	7-8	4-6	6-75	5-6	7-8	7-8	7-8	7-8	6-8	5.5-7.3		6-7.5	6-5.5	5-6.5	5-6.5	5-7.5	
Alkalinity as $CaCO_3$	310	40	1	130	3	3	3	460	200	64	312	300	1,826	142	50	7	20	10	1,193	92
BOD_5 Bio Oxygen Demand	1,470	200	138	130	2	2	2	23	570	1	16	3	2,557	198	43	7	18	9	2,634	127
COD Chemical Oxygen Demand	1,844	430	208	222	4	4	4	40	890	2	28	5	3,681	286	75	12	32	16	3,816	184
TOC Total Organic Carbon	330	50	43	50	1	1	1	9	187	1	7	2	682	53	16	3	7	4	712	34
TKN Total Kjeldahl Nitrogen	260	60	4	50	2	1	1	7	40	3	4	3	435	34	5	10	10	6	466	22
TSS Total Suspended Solids	7	8	1	25	1	1	1	23	1,684	40	60	1	1,052	144	227	14	27	17	2,137	103
TDS Total Dissolved Solids	914	250	9	435	8	8	8		677	145	216	1,227	5,397	419	910	104	267	127	6,805	328
Nitrate, Nitrite-N				10	45	1	1	5	7	1	4	1	75	18		7	2	1	240	12
Ammonia		24		20					2				46	4					46	2
RDX	120			27									147	11					147	7
HMX				20									20	2					20	1
TNT	128			27									155	12					155	7
Acetic Acid	72	480					500						1,052	82			20	10	108	52
Hexamine		576											576	45					576	28
Cyclohexanone	648												648	50					648	31
Propyl Alcohol		816											816	63					816	39
Propyl Acetate		96											96	7					96	5
Nitromethane		312											312	24					312	15
Formaldehyde		8,640											8,640	670	91				8,731	421
Phosphate								10	2	50	2	2	66	5					66	3
Sulphate			2	75	2	2	2		104	40	185	417	829	64		1		1	831	4
Acetic Anhydride						400							400	31					400	19
Amine										60			60	5					60	3
Organic Nitrogen			3	30		1	1		4				69	5					69	3
Toluene	40												48	4					48	2
Stearic Acid	24												24	2					24	1
Acetone		696											696	54					696	34
Methyl Acetate		312											312	24					312	15
Formic Acid		2,808											2,808	218					2,808	135

[a] Stated in pounds per day unless otherwise noted

[b] Gallons per day

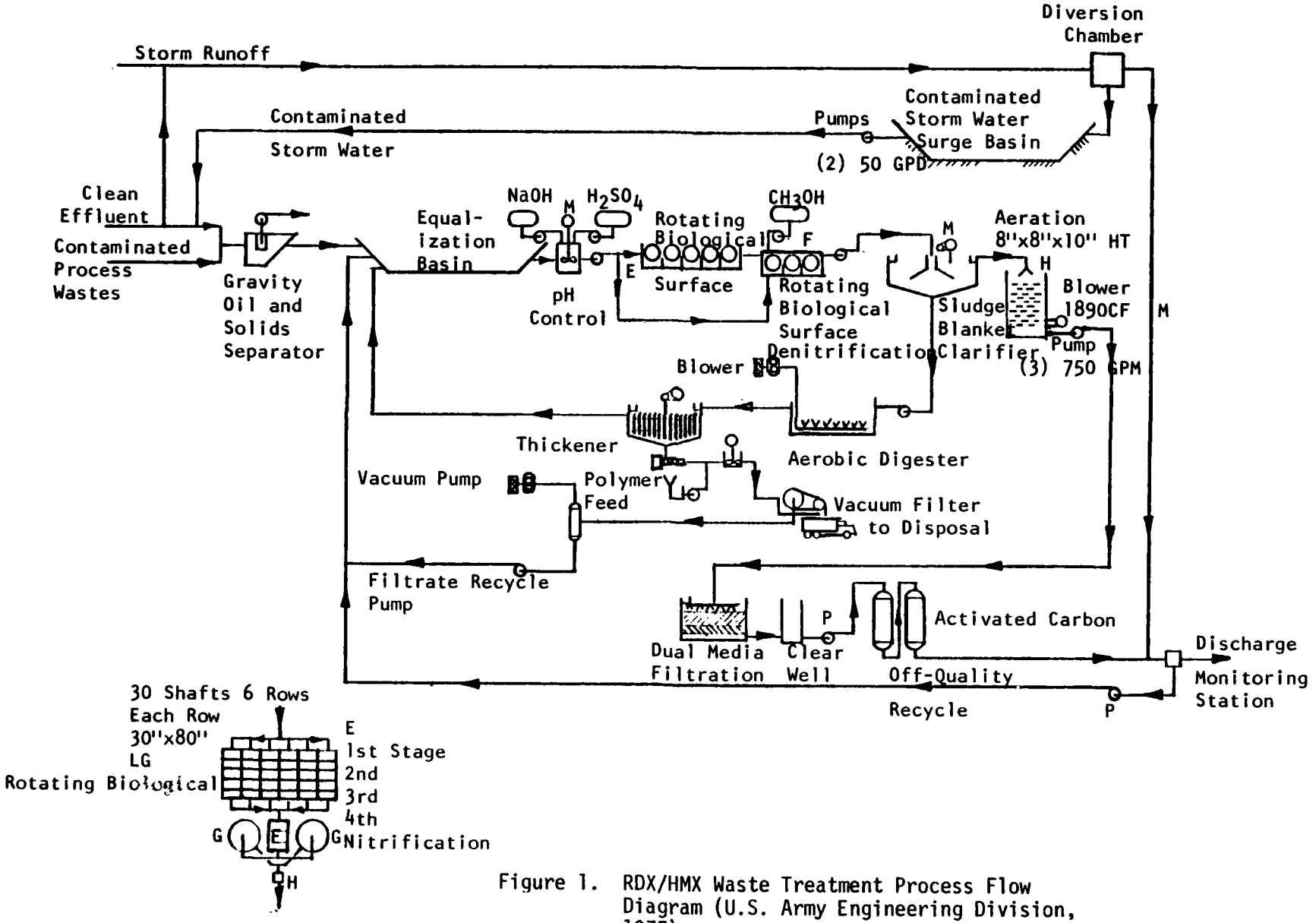


Figure 1. RDX/HMX Waste Treatment Process Flow Diagram (U.S. Army Engineering Division, 1977)

Preliminary design concepts generated in the absence of experimental data describing the wastewater treatment plant for the RDX/HMX Site "X" facility are shown in Figure 1. As conceived, the wastewater treatment facility consisted of primary, secondary and tertiary level treatment. Primary level treatment was to consist of an oil-solids separator, equilibrium basin and pH adjustment. In the secondary level treatment, rotating biological contactors (RBC) were to be employed to reduce the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of the effluent to acceptable levels. Denitrification followed the aerobic treatment. The sludge was to be removed from the water and prepared for disposal. The tertiary treatment or polishing step consisted of dual media filtration and carbon adsorption.

The speculative nature of the preliminary design lead ARRADCOM (Army Armament Research and Development Command) to contract MERADCOM (Mobility Equipment Research and Development Command) and Atlantic Research Corporation (ARC) to perform bench-scale and pilot-scale studies to evaluate the treatability of the "X" facility wastewaters with rotating biological contactors. These contracts were for 6-month experimental studies aimed mainly at determining feasibility and obtaining a data base for design criteria for the "X" facility wastewater treatment plant. The data from the MERADCOM bench-scale study were to be input to ARC so that the pilot-plant could be quickly optimized. However, technical difficulties with the bench-scale unit forced the two studies to be performed in parallel.

The bench-scale evaluated both aerobic degradation and anaerobic denitrification. However, a decision was made not to experimentally characterize biodenitrification at the pilot-scale. This decision was based on the following:

1. Critical time restrictions on the length of the experimental study dictated that the major problem namely, COD/BOD reduction for a wastewater containing very high concentrations of formaldehyde, be emphasized.

2. Bench-scale studies indicated that no viable biomass could be developed in an anaerobic RBC following an aerobic RBC.

3. For anaerobic RBC proceeding the aerobic RBC, the level of confidence that anaerobic denitrifiers would be viable in the presence of high formaldehyde concentrations was low. A prolonged experimental program was considered necessary. Alternatives such as segregating the formaldehyde containing process effluent before denitrification would lengthen the experimental study to beyond allowable time requirements.

This report presents the results of the pilot-scale evaluation of aerobic rotating biological contactor treatment of synthetic "X" facility wastewaters. The results of the bench-scale study are presented elsewhere.

B. Program Objectives

The principal objectives of the program were (1) to evaluate the ability of the rotating biological contactor (RBC) aerobic system to remove organic material from the wastewater generated by the RDX/HMX Site "X" facility and (2) determine the suitability of this treatment for industrial applications. This evaluation was performed on two synthetic streams. The "A" stream which included 546,200 gallons per day from the heat exchanger condensate and the "B" stream where the condensate was excluded. This condensate (relatively clean water which becomes contaminated as a result of heat exchanger failure) is a potential means to reduce formaldehyde concentrations to less inhibitory levels, if so required.

It was recognized at the onset of the experimental program that an exhaustive experimental characterization of the RBC effluent to establish treatment efficiency for all known conventional, nonconventional and toxic pollutants was well beyond the permissible scope of this study. The time constraint of 6 months and the attendant level of effort imposed a very practical limit on the extent of experimental characterization. The experimental program, therefore, concentrated on the major needs, namely COD/BOD reduction in the formaldehyde containing wastewater via biodegradation and the suitability of the RBC for the application. The goal of the RBC secondary treatment was a 95% reduction in BOD load. This percentage BOD reduction will be required to maximize the effectiveness of any subsequent advanced secondary and tertiary level treatment steps which may be necessary to achieve anticipated forthcoming effluent limitations.

In addition to determining the feasibility of aerobic biological treatment of these wastewaters, information on hydraulic loading, sludge handling characteristics and effluent toxicity were also to be provided as time and resources allowed. The data base will be used to further define the design criteria for the wastewater treatment facility.

II. EXPERIMENTAL PROCEDURES

A. Layout of Pilot Unit

The pilot scale rotating contactor (RBC) evaluation of the RDX/HMX Site "X" wastewaters was carried out utilizing the set-up as shown in Figure 2. Two 12-foot diameter collapsible rubber tanks were used as feed tanks. The synthetic influent was fed from one tank while the other was being cleaned and refilled. The influent was pumped into a 20-gallon pH adjustment tank. The pH adjusted influent was then siphoned into the RBC.

A four stage aerobic RBC pilot plant manufactured by the Environmental Systems Division of Geo. A. Hormel and Company was utilized in this evaluation. This unit, shown in Figure 3, has 4 stages which can be arranged in series, parallel or any combination thereof. Each stage has twelve 47-inch diameter polyethylene discs packaged together and attached to a central shaft. The area of each individual disc is 35 square feet or 420 square feet per stage. The total disc area of the pilot unit is 1,680 square feet. The discs were rotated by means of 3/4 hp motor. The speed of rotation of the discs could be varied from 0 to 20 rpm.

The effluent from the RBC flowed into a 10-foot diameter clarifier tank. The overflow from the clarifier was filtered through a sand-gravel filter. The filter effluent was pumped to a 9" diameter x 48" high carbon column filled with Filtersorb 400 granular carbon. After carbon filtration, the filtrate was sewered.

B. Synthetic "X" Facility Wastewater Composition and Preparation

1. Composition of Synthetic "X" Facility Wastewater

On March 10, 1979, a project initiation meeting was held at ARRADCOM, Dover. During this meeting, the "X" facility wastewater characterization developed by the U.S. Army Engineering Division (see Table 1) was discussed. After review of the wastewater flow and contaminant levels, ARC was instructed to evaluate two synthetic wastewaters. The anticipated upper and lower compositions of these two synthetic wastewaters are shown in Table 2. Condition "A" is the total dry weather wastewater and is similar to that shown in Table 1. For condition "B", the 546,200 gallons per day from the heat exchanger condensate are eliminated from waters entering the wastewater treatment facility. The resulting stream has a flow of 998,300 gallons per day and except for the sulfate concentrations, the concentrations of the contaminants are $\sim$1.55 times condition "A".

2. Preparation of RBC Influent

The synthetic influent water for the pilot scale evaluation was formulated in 1500 gallon or 3000 gallon batches. The materials, their purity, source and quantities used to make up these synthetic influents are presented in Table 3. The maximum concentration expected for each chemical

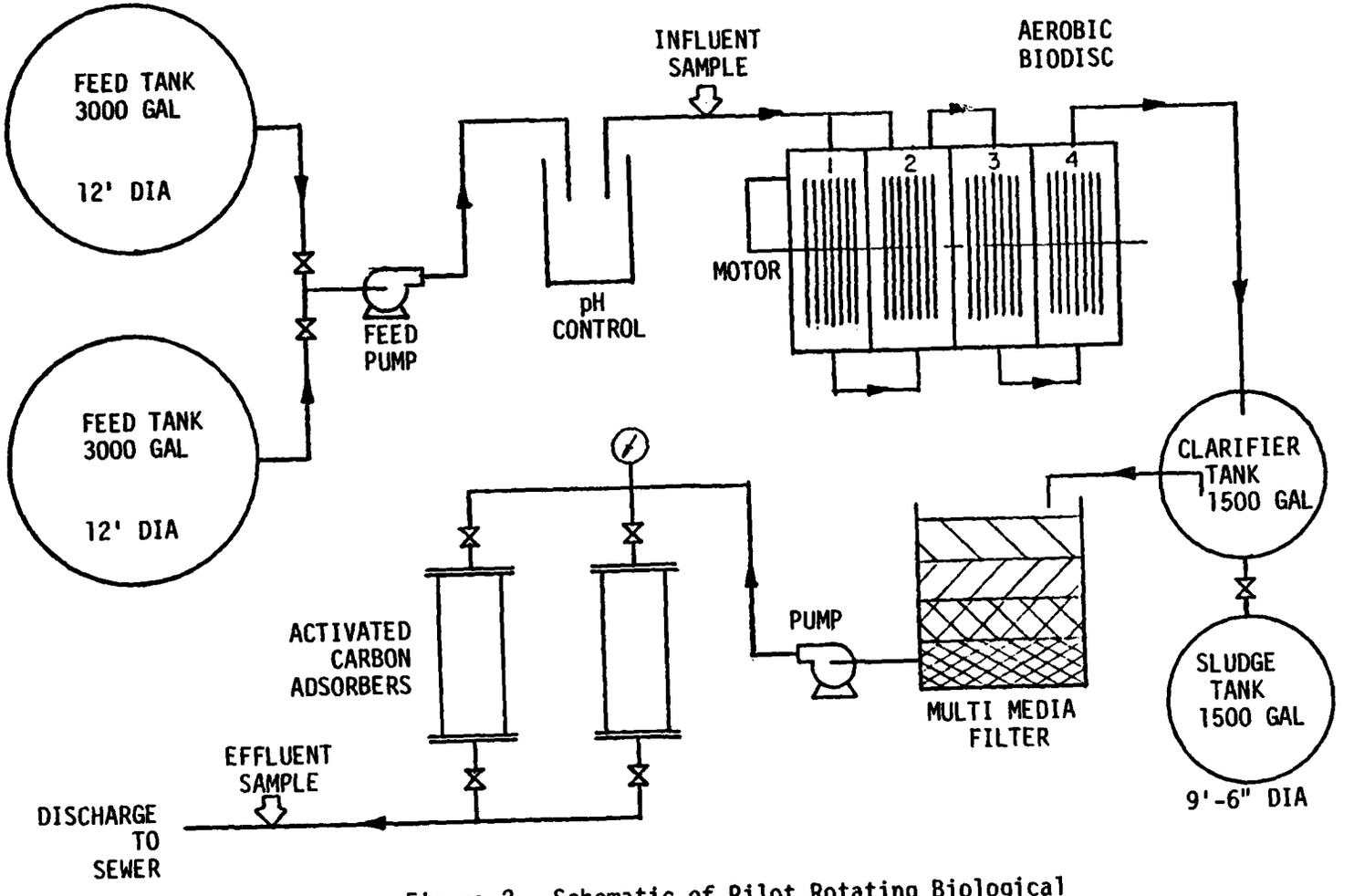


Figure 2. Schematic of Pilot Rotating Biological Contactor Facility

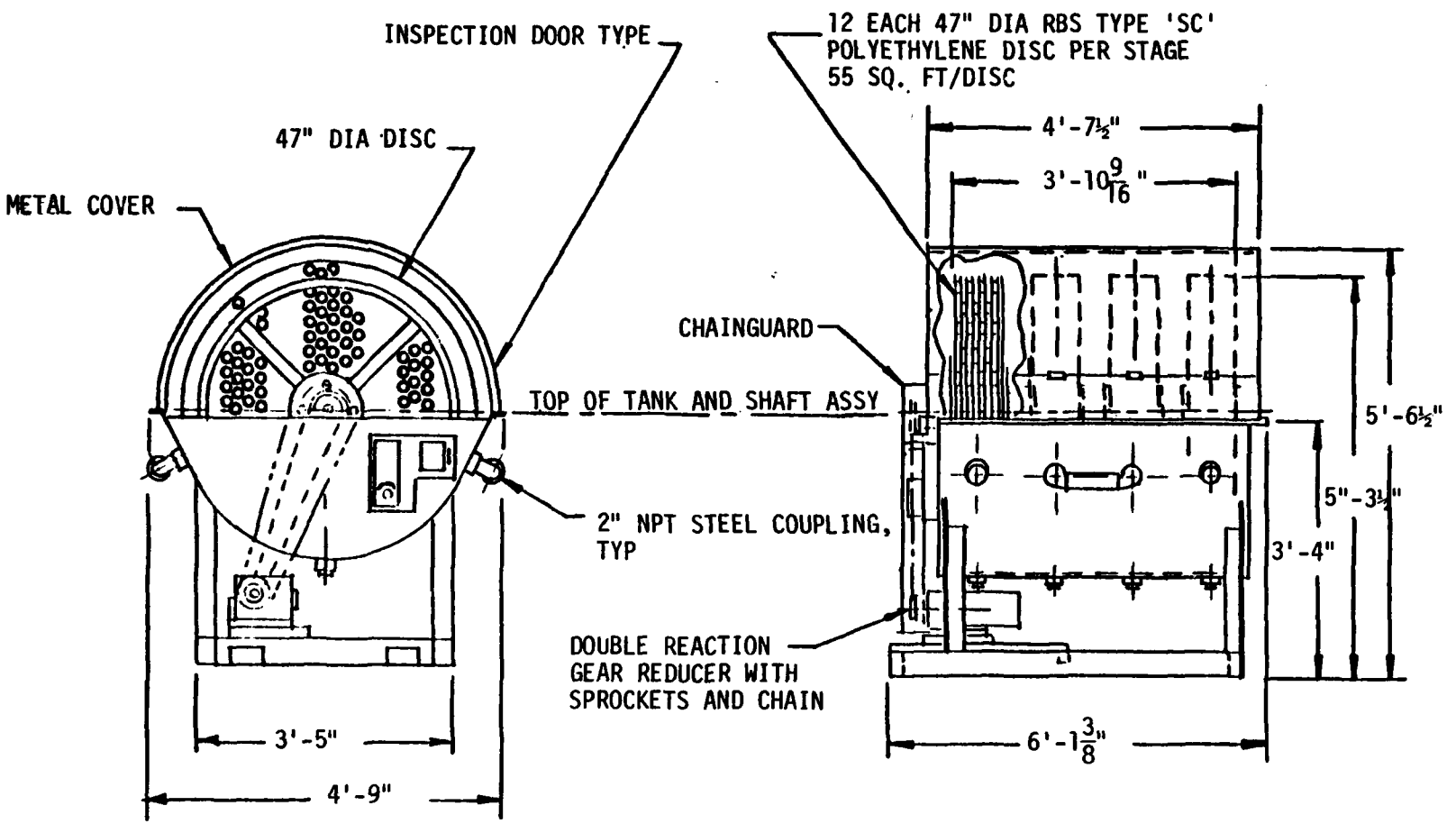


Figure 3. Four Chamber RBC Pilot Unit

Table 2. Range of Expected Contaminants in Influent to Wastewater Treatment Facility at Site "X"* (ARRADCOM, 1979)

	Condition A		Condition B	
Total Flow, Gal/Day	1,544,500		998,300	
Contaminants:	lb/day	mg/l	lb/day	mg/l
NO_3-NO_2-N	230	18	225	27
Ammonia	19-46	2-4	19-46	2-6
RDX	60-147	5-11	60-147	7-8
HMX	20	2	20	2
TNT	64-155	5-12	64-155	8-19
Acetic Acid	420-1052	33-82	420-1052	51-127
Hexamine	464-576	36-45	464-576	56-70
Cyclohexanone	518-648	40-50	518-648	63-78
1-Propanol	653-816	51-63	653-816	80-98
Methyl Acetate	250-312	20-24	250-312	30-38
Propyl Acetate	77-96	6-7	77-96	9-12
Formic Acid	2246-2808	175-218	2246-2808	272-338
Nitromethane	250-312	20-24	250-312	30-38
Formaldehyde	6912-8640	539-670	6912-8640	836-1039
Phosphate**	66	5	56	7
Sulphate	1102	85	829	100
Acetic Anhydride	400	31	400	48
Amine	60	5	60	7
Organic Nitrogen	69	8	69	12
Toluene	34-48	3-4	38-48	5-6
Stearic Acid	12-24	1-2	12-24	1-3
Acetone	566-696	43-54	556-696	67-84

* Condition A: Total wastewater includes heat exchanger condensate.
Condition B: Total wastewater without heat exchanger condensate.

** Contaminant level is advisory only. Firm number cannot be determined until water treatment additive is selected.

Table 3. Composition of Synthetic Feed to Pilot RBC

Constituent	Purity	Source	Condition A Amount Added	Condition A Concentration (mg/l)	Condition B Amount Added	Condition B Concentration (mg/l)
Water			3000 gallons		3000 gallons	
Acetic Acid	Glacial	Textile Chemical Company	920 ml	82	1425 ml	127
Hexamine	99%	Baker	500 g	44	795.5 g	70
Cyclohexanone	97%	Textile Chemical Company	(610 ml)[1] 1350 ml	113	(934 ml)[1] 2093 ml	175
1-Propanol	98%	Textile Chemical Company	903 ml	63	1397 ml	99
Methyl Acetate	99.5%	Fisher	292 ml	24	462 ml	38
n-Propyl Acetate	97%	Textile Chemical Company	89 ml	7	153 ml	12
Formic Acid	90%	Textile Chemical Company	2262 ml	218	3501 ml	338
Nitromethane	95.8%	Baker	239 ml	24	378 ml	38
Formaldehyde	40%	Textile Chemical Company	19108 ml	674	29626 ml	1039
Ammonium Phosphate	98%	Fisher	(160 g)[2] 320 g	560 PO_4^{-3}	(234 g)[2] 448 g	7.00 PO_4^{-3}
Ammonium Sulfate	99.5%	Baker	1112 g	85 as SO_4^{-2}	1293 g	100 as SO_4^{-2}
Acetic Anhydride	97%	Baker	388 ml	31	503 ml	48
Monomethylamine	40%	Baker	71 ml	2.5	99.4 ml	3.5
Dimethylamine HCl	95%	Baker	44 g	2.5	61.6 ml	3.5
Toluene	99.5%	Baker	52 ml	4	78 ml	6
Stearic Acid	U.S.P.	Baker	23 g	2	34.5 g	3
Acetone	94%	Textile Chemical Company	775 ml	54	1206 ml	84
TNT[3]	Unknown	HAAP	137.4[3]	12	213[3]	19
RDX[4]	Unknown	HAAP	126[4]	11	195.3[4]	18
HMX[5]				2		2

[1] Amount added was ~2X required amount.

[2] Amount actually added was ~2 times this amount to bring PO_4^{-3} levels to point where efficient biodegradation could occur.

[3] Dissolved in 292 ml of methyl acetate (A) or 462 ml methyl acetate (B).

[4] Dissolved in 775 ml of acetone and 1350 ml of cyclohexanone (A) or 1206 and acetone and 2093 at cyclohexanone (B).

[5] Added as impurity in the RDX.

for each condition was used to make up the synthetic wastewater influent. Initially, the acids were added to 20 gallons of water and neutralized to pH 7 with ammonium hydroxide and sodium hydroxide. This neutralized mixture was then added to the tank. The procedure was later abandoned and the acids were added directly to the influent tank with neutralization accomplished after all the chemicals had been added to the water. The TNT was dissolved in methyl acetate for transport and addition to the synthetic feed. The RDX and HMX were dissolved in a mixture of cyclohexanone and acetone before addition to the feed. All other chemicals were added directly to the water. In order to promote dissolution and keep the materials in solution, the liquid in the influent tank was continuously stirred with a 3/4 hp submersible pump.

3. Adjustment and Control of pH

Initially, the pH in the influent tank was adjusted to between 7.0 and 8.0 with 2 liters of ammonium hydroxide and ~2600 g of sodium hydroxide. However, the pH of the synthetic influent dropped to ~5.0 in one to two days after its preparation. In order to maintain a relatively constant influent pH, sodium hydroxide was added to the tank on a daily basis. This method of pH adjustment did not provide a constant pH to the RBC. A large amount of biological growth was also observed in the feed tanks.

In order to remedy this situation, a 20-gallon pH adjustment tank was placed in the feed line to the RBC. The influent was pumped into this tank, and the pH adjusted with concentrated sodium hydroxide by a Fisher Model 650 pH Meter Controller. This set-up provided a constant pH influent to the RBC. In addition, the pH in the main feed tank could be maintained below 5 to discourage microbial growth.

C. Start-Up of RBC Unit

The aerobic RBC was inoculated on May 24, 1979. The initial inoculum consisted of ~1/2 gallon of primary effluent from Arlington Sewage Treatment Plant, 50 ml of formaldehyde and 50 gm of nutrient broth per chamber. Some growth was observed in the chambers. However, after streaking agar plates with the primary effluent, it was determined that the primary sewage effluent had a low bacterial population. The RBC was reinoculated on May 30, 1979. This inoculum contained 1 gallon of primary effluent, 50 ml of formaldehyde and 50 ml of corn steep liquor per chamber. The RBC was allowed to grow in a static mode for 10 days with daily feeding of 50 ml of formaldehyde and 10 ml of corn steep liquor per chamber. Significant growth on the discs was observed.

On June 8, 1979, 3,000 gallons of feed solution were made up. This mixture contained the primary ingredient in the condition "A" influent in the following proportions:

- 700 ppm formaldehyde

- 82 ppm acetic acid

- 37 ppm acetic anhydride

- 51 ppm cyclohexanone

The solution was neutralized with ammonium hydroxide and sodium hydroxide. The hydraulic loading to the RBC was 0.18 gal/day/sq. ft. A significant increase in the microbial growth on the discs in the first two chambers was observed. After seven days, a new influent solution was made up. This solution contained all the components of the condition "A" wastewater.

D. Sampling and Analysis Protocols for RBC

Samples from the RBC were drawn every morning between 8:00 a.m. and 9:00 a.m. Sampling points were at the inlet to the first chamber of the pilot unit, outlets of chambers 1, 2, 3 and 4 and the outlet of the carbon column. The samples were carefully withdrawn from these points with a 50 ml pipet so as not to increase the dissolved oxygen (DO) content of the water. The temperature of the influent and first chamber were recorded at the time of sample collection.

The schedule which was followed for the routine analytical evaluation of the RBC is presented in Table 4. The analytical protocols used are discussed in the following paragraphs.

The dissolved oxygen readings were taken every morning with a YSI Dissolved Oxygen Meter. This meter was calibrated daily on air according to the manufacturer's instructions.

The pH was then measured with an Orion pH Meter. The pH meter was calibrated with Gram-Pac buffer salts, pH 4.01 and 9.18. The alkalinity of the solutions were then determined by titrating measured amounts of sample with standard sulfuric acid to a pH end point as specified in Section 403 of Standard Methods for Water and Wastewater Analysis (1976).

The residue procedures are listed in Section 208 of Standard Methods for Water and Wastewater Analysis (1976). For total solids, measured amounts of sample were oven dried daily in tared crucibles, cooled and reweighed. Twice weekly, the dried samples from total solids were ignited in a muffle furnace for total volatile solids. For total suspended solids, measured amounts of sample were filtered through tared gooch crucibles, oven dried, cooled and reweighed.

Nitrate and ammonia concentrates were measured daily using respective Orion electrodes and pH meter. The procedures were later changed to Hach test kits for convenience. Later in the program, it was determined that formaldehyde interfered with both of the ammonia procedures yielding values that were significantly higher than actual values.

Formaldehyde was determined daily. Samples were filtered through a 0.45 μ Millipore filter to remove optical impurities. Sulfuric acid and

Table 4. RBC Sampling and Analysis Schedule

	Inf.	C-1	C-2	C-3	C-4 Eff.	Carbon Effluent
Temperature	D	D				
DO	D	D	D	D	D	D
pH	D	D	D	D	D	D
Alkalinity	D	D	D	D	D	D
Nitrate					D	
Ammonia	D	D	D	D	D	
Total Solids	D				D	D
TVS	2W				2W	2W
TSS		2W	2W	2W	2W	
Formaldehyde	D	D	D	D	D	
COD	D	D	D	D	D	D
BOD	2W→D	2W→D	2W→D	2W→D	2W→D	
TOC	D	D	D	D	D	D
RDX	D	D	D	D	D	D
HMX	D	D	D	D	D	D
TNT	D	D	D	D	D	D

chromotropic acid indicator were added to samples which were then heated on a steam bath. After dilution, the absorbances were read on a Cary 14 Spectrophotometer and compared to a standard curve to determine formaldehyde concentrations.

The Standard Methods procedure for chemical oxygen demand (COD) in Section 508 was followed. Samples filtered through a 0.45 μ Millipore filter were tested daily. Measured portions of samples were prepared with mercuric sulfate, potassium dichromate and concentrated sulfuric acid and fixed with silver sulfate. The samples were refluxed for 2 hours, diluted and titrated with ferrous ammonium sulfate and ferroin indicator. A blank and a standard were run with each set of samples. The results of this analysis were soluble CODs.

Biochemical oxygen demand (BOD) was originally determined twice a week. Later the test was performed 5 days a week to provide sufficient data. The procedure followed is listed in Section 507 of the Standard Methods. Dilutions of filtered, pH 7 adjusted samples, were seeded and incubated for 5 days. At the end of the incubation period, dissolved oxygen readings were taken with a calibrated YSI Dissolved Oxygen Meter and the soluble BOD calculated.

Total organic carbon determinations were made on a Beckman 915a Total Organic Carbon Analyzer with a model 865 infrared detector. The total carbon channel employed a cobalt nitrate catalyst on asbestos at 950°C and the inorganic channel, a phosphoric acid catalyst at 170°C. An air flow of 150 cc/min was used. Samples of about 20 μl were injected and the response compared graphically to calibration curves prepared daily.

RDX, HMX and TNT were analyzed by high performance liquid chromatography (HPLC) on a Perkin Elmer 601 HPLC system equipped with a model 420 autosampler and an LC55 variable wavelength UV detector. The aqueous samples were filtered prior to analysis through a 0.45 μ Millipore filter. The following conditions were employed:

- Column: Partisil PXS10/25 ODS-2
- Solvent: 35% CH_3CH; 15% CH_3OH; 50% H_2O
- Flow: 0.5 ml/min
- Detector: 230 nm
- Sample size: 20 μl

A detection limit of about 0.1 ppm was possible without concentration or use of larger sample volumes.

E. Laboratory Settling Tests

In order to obtain information for clarifier and filter design criteria, laboratory settling tests were conducted. For these tests, samples of effluent from the RBC were collected in four 500 ml graduated cylinders. Two 100 ml samples were collected in beakers, one before and one after the 4 graduated cylinders. The pH, temperature and total suspended solids were determined on these 100 ml samples.

To initiate the settling tests, the graduated cyclinders were inverted to thoroughly suspend the solids. After 1 minute, 100 ml was pipeted from the top of cylinder #1. The top 100 ml was pipeted from cylinder #2 at the end of 2 minutes; cylinder #3 at 3 minutes and cylinder #4 at 5 minutes. Total suspended solids in the 100 ml portions removed were determined. The volume of sludge in the bottom of each cylinder was determined at 1, 2, 3, 5, 10, 15, 20, 30, 45 and 60 minutes. The heights of the graduated cylinders were measured so that the depth of sludge could be calculated.

F. Environmental Stress Cracking Tests

Certain chemicals accelerate the deterioration of plastics when placed under stress. In order to determine if the "X" facility wastewater would promote premature failure of the RBC disc materials, an environmental stress crack test was performed. This test was performed by Autotrol Corporation on the influent wastewater ("B" stream) and Chamber I water collected on 23 October 1979.

A modification of the ASTM test method D1693 (bent strip test) was used. This procedure was modified to facilitate use as a screening procedure as follows:

1.	Test Solution:	RBC influent and Chamber I waters
2.	Test Temperature:	35°C
3.	Test Specimen:	Standard High Density Polyethylene (HDPE) copolymer conforming to D1693, Condition B
4.	Number of Test Specimens:	5

The number of test hours until 50% of the specimens failed (F_{50}) was determined. This number was then compared to the F_{50} of reference materials to determine if the wastewaters were aggressive or non-aggressive. The following materials were used as reference materials.

- 10% Igepal (aggressive); F_{50} = 7-22 hours
- Deionized Water (non-aggressive); F_{50} = 132-143 hours
- Air (non-aggressive); F_{50} = 166 hours

G. Identification of RBC Microorganisms

Samples from the RBC Chamber 1, 3 and 4 were collected for identification of microbial constituents. Each sample was streaked directly onto BBL Trypticase Soy Agar plates. Aliquots of these samples were also added to BBL Trypticase Soy Broth (for bacteria) and to Malt Extract Broth (for filamentous fungi). Bacterial colonies which grew on the agar plates were examined for different morphologies. Those colonies which appeared to be different were picked and streaked on Eugon Agar plates. The Eugon Agar plates were examined under long wavelength UV light. The bacteria were tested for their ability to form acid from glucose aerobically and for their reaction in Litmus milk.

H. Aquatic Toxicity Tests

Four synthetic wastewater samples were evaluated for their toxic effects on aquatic organisms:

- influent condition "B" 4 October 1979
- effluent condition "A" 14 December 1979
- effluent condition "B" 4 October 1979
- carbon filtered effluent condition "B" 2 November 1979
- effluent condition "B" without TNT 1 December 1979

The wastewaters were collected and tested on the same day. The influent was collected after pH adjustment, just before the wastewater entered the RBC. The effluent was collected from the overflow from the 4th chamber of the RBC. The carbon filtered effluent was collected after sand filtration and passage through two and six-foot lengths of fresh activated carbon (Filtersorb 400).

The test organism was the bluegill sunfish (*Lepomis machrochirus*). The fish tested had an average length of 3.2 cm and an average weight of 0.9 gm. The length of the longest fish tested was no more than twice that of the smallest fish. The sunfish were purchased from a fish farmer in Ohio. The fish were held in a 2280 liter polyethylene pool for at least 14 days prior to testing. No mortality was observed in the fish during the 48 hours prior to testing. Also the fish were not fed 24 hours before the testing.

The holding water was a mixture of dechlorinated tap water and carbon and resin filtered tap water. This water had the following characteristics:

- Temperature 20±2°C
- Hardness 51±8 ppm
- Alkalinity 120±5 ppm

- pH 6.5 - 6.8

- Dissolved Oxygen 7.8 - 8.7

- Residual Chlorine = below detection limit (10 ppb)

The test methods recommended by Peltier (1978) were employed. Range-finding or preliminary static tests were conducted to establish concentrations for the definitive toxicity tests. The definitive static toxicity tests were conducted in the 19 liter glass aquaria bonded together with a silica sealer. Duplicate chambers were used for each concentration and the chamber order was randomized in the tests. Each chamber contained ten liters of test solution and ten fish. Four to seven effluent concentrations were tested in an experimental series. The concentrations evaluated for each wastewater are presented in Table 5. Each solution was analyzed for pH, D.O., alkalinity, ammonia, nitrate, COD, BOD, formaldehyde, RDX, HMX and TNT. The photoperiod was 10 hours per day. The temperature of the test solutions was between 18 and 20°C.

The results from each test were evaluated using the Litchfield-Wilcoxon method to calculate LC50 values and 95% confidence limits.

I. Mutagenicity Screening of the RBC Effluent

The Ames test was used to screen the effluents from the RBC for mutagenic acitivity. The basis of the Ames test is the back mutation (reversion) of histidine requiring mutants of *Salmonella typhimurium* LT2 to non-histidine requiring cells when the bacteria are exposed to chemical mutagens. Because different types of DNA alterations are caused by different kinds of chemicals, several histidine-requiring mutants were used for this general mutagenic screening. The five strains of *Salmonella typhimurium* used in our tests, TA_{1335}, TA_{100}, TA_{1537}, TA_{1538}, TA_{98} were supplied by Bruce Ames (University of California, Berkley). These tester strains have three different histidine mutations (1) a cell wall defect *rfa* which increases the cell's permeability of large molecules, (2) a detection (ΔuvrB) which decreases the cell's ability to repair damaged DNA and (3) an episome (R factor) which makes the cell susceptible to mutation by more kinds of chemicals. The genotypes of the *S. typimurium* used in the test are shown below (Ames *et al.*, 1975).

Histidine Mutation			Additional Mutations		
*his*G46	*his*C3076	*his*D3052	LPS	Repair	Factor
TA_{1535}	TA_{1537}	TA_{1538}	*rfa*	ΔuvrB	-
TA_{100}		TA_{98}	*rfa*	ΔuvrB	+R

Table 5. Concentration Ranges of Wastewater for Aquatic Toxicity Tests

Influent Condition "B" with TNT	Effluent Condition "B" no TNT	Effluent Condition "B" with TNT	Effluent A with TNT	Carbon Filtered Effluent Condition "B" Containing TNT
14	100	80	85	60
11	81	60	62	46
8	63	46	46	35
5	50	35	35	
2	41	26	26	
.5				

Each culture was grown in Oxoid Nutrient Broth No. 2[1] and was checked for integrity before each test was performed. This check was necessary since the R factor and cell wall defect and histidine requirements are readily lost. The integrity checks included the following procedures as specified by Ames *et al.* (1975).

- histidine requirement
- crystal violet inhibition
- ampicillin resistance
- UV resistance
- spontaneous reversion rate

The following samples were collected for mutagenicity testing:

- ARC RBC Effluent ("B" solution - explosives) - 1 November, 1979
- ARC Carbon Column Filtrate ("B" solution - explosives) - 1 November, 1979
- Ft. Belvoir RBC Effluent ("A" solution - no explosives) - 13 November, 1979
- Iowa Pink Water
- ARC RBC Influent ("B" solution - no TNT) - 21 November, 1979
- ARC RBC Effluent ("B" solution - no TNT) - 21 November, 1979
- ARC Carbon Column Filtrate ("B" solution - no TNT) - 21 November, 1979

[1] Ingredients used to prepare Oxoid Nutrient Broth No. 2 were as follows:

10 gm Lab Lemco Powder (Meat Extract)	10 gm Peptone
5 gm Sodium Chloride	1 ml Water

Spot tests recommended by Ames *et al.* (1975) were used to screen the chemicals for mutagenicity. This method allows mutagenicity to be determined even if the material is toxic to the tester strains. In the spot test method, a 1/2 inch filter paper disc was placed on the top agar. The plates for this test were prepared by placing a top agar ([1]) layer over Vogel-Bonner Medium E ([2]), a minimal medium. A 0.1 ml sample of the prefiltered RBC sample or 1 to 10 µg of known mutagens were added to the filter disc. These chemicals diffused out into the top agar during incubation. A zone of microbial inhibition around the disc is indicative of toxicity. While a zone of revertants outside the inhibition zone indicates mutagenicity.

In addition, the RBC effluent with metablic activation was also tested. This metabolic activation is induced by the S9 mix added to the top agar. The S9 mix contains 1 ml of a liver homogenate (S9) from rats induced with Aroclor 1254 and the following ingredients:

- 0.2 ml of 0.4M $MgCl_2$
- 0.20 ml of 1.65M KCl
- 0.05 ml of 1M glucose-6-phosphate
- 0.40 ml of 0.1M NADP
- 5.00 ml of 0.2M sodium phosphate (pH 7.4)
- 3.35 ml of water

([1]) The top agar contained 0.6% Difco agar, 0.5% NaCl, 0.05 mM histidine and 0.05 mM biotin.

([2]) The Vogel-Bonner Medium E contained the following ingredients per liter: 15 gm Difco agar, 50 gm glucose, 0.2 gm $MgSO_4 \cdot 7H_2O$, 2 gm citric acid monohydrate, 10 gm K_2HPO_4 (anhydrous) and 3.5 gm of $NaHNH_4PO_4 \cdot 4H_2O$.

III. EVALUATION OF RBC FOR DEGRADATION OF SITE "X" WASTEWATERS

A. Pilot Unit Operations on the "A" Wastewater

The "A" stream was introduced into the pilot RBC on 15 June 1979 after biological growth in the unit was established as discussed in Section IIC. The initial feed was made according to the concentrations given for the maximum "A" stream values presented in Table 2, however, no explosives were added. This solution was neutralized to ~pH 7 with 2 liters of 40% ammonium hydroxide and 2600 g of sodium hydroxide. The ammonium hydroxide was added to supply a nitrogen source for the microbial growth. The hydraulic loading to the RBC was 0.238 gallons/sq. ft/day or an influent flow rate of 400 gal/day The RBC was operated in a series mode, *i.e.* influent → chamber 1 → chamber 2 → chamber 3 → chamber 4 → effluent.

The results obtained from the pilot RBC operation during the period from 15 June to 24 June were very erradic. Several adjustments had to be made to the pumping system in order to maintain a constant hydraulic loading to the RBC. During this period of operation, COD reduction varied between 60 and 80%. However, good formaldehyde reductions were obtained. The initial growth, that was observed uniformly throughout the chambers before the "A" stream operation, sloughed off. This growth was replaced by a cream color fungus in chamber 1. Chambers 2, 3 and 4 had no significant biological growth on the discs. A picture of the pilot RBC in operation is shown in Figure 4. A close-up photograph of the cream colored fungus can been seen in Figure 5.

The daily analyses for the RBC operation on the "A" stream are compiled in Appendix A of this report. The major events in the operation and the percentage COD and BOD reduction are presented in Figure 6.

Several problems were encountered during the initial operation on the "A" stream. These problems included:

- low COD/BOD reductions
- heavy microbial growth in the feed tank
- variation of pH in the feed tank
- erradic analytical results
- low dissolved oxygen levels in

The approaches taken to solve these problems and the results obtained are discussed in the following sections.

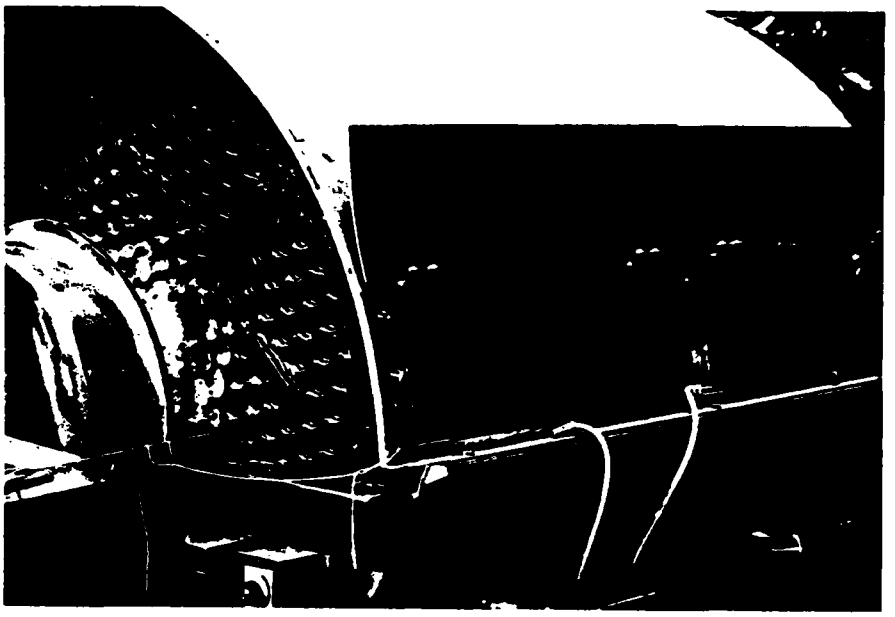


Figure 4. Photograph of Pilot RBC Unit in Operation

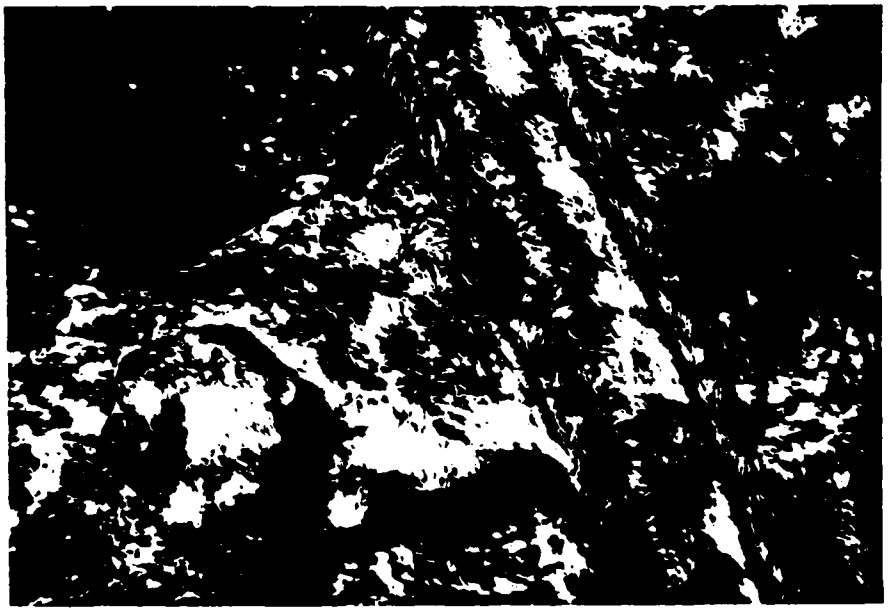


Figure 5. Close-Up Photograph of Fungal Growth on Discs in Chamber 1

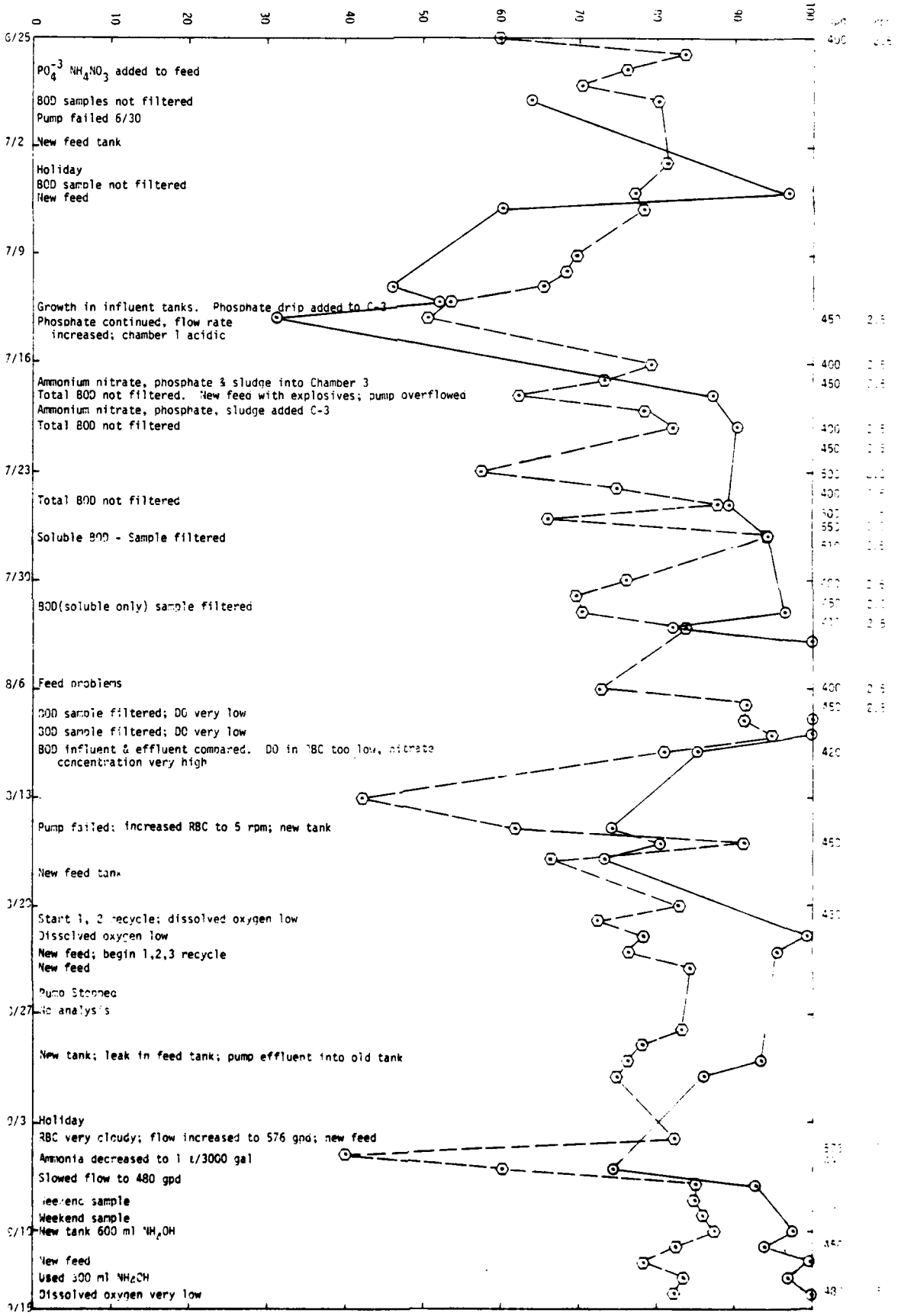


Figure 6. Operational Results on the "A" Wastewater

1. Approaches to Improving COD and BOD Reduction

In order to improve the COD and BOD reduction, the molar C:N:P ratio of the mixed feed was evaluated. This ratio was 100:12.8:0.12. Thus, the phosphorus content of this influent was significantly less than the 100:16:1 recommended for good microbial growth. It was also possible that nitrate-nitrogen was required by the RBC organisms. On 26 June, one pound each of ammonium nitrate and sodium phosphate was added to the feed tank. No improvement in the COD reduction was observed; also there was no noticeable increase in the biological growth on chambers 2, 3 and 4. The nitrate levels in the effluent increased on 28 June to 3 July indicating that nitrates were not being used by the RBC organisms. On 8 July, a phosphate drip was added to chamber 3.

The 10% phosphate solution was pumped from a reservoir into the third chamber at a rate of 2 ml/min by means of a peristaltic pump. The additional phosphate did not improve the growth or the degradation rate in chambers 3 or 4. During the next several weeks, various formulations of phosphate, sewage sludge and corn steep liquor were dripped into chamber 3. The addition of corn steep liquor promoted growth on the discs in chamber 3. and 4. An apparent increase in COD reduction was also observed. However, as soon as this drip was discontinued, the growth in chambers 3 and 4 sloughed off. The addition of phosphate to chamber 3 appeared to have no significant effect on the degradation.

The explosives were added to the "A" stream on 18 July. In addition, the phosphate concentration in the new feed was double to 5.26 x 10^{-4}M or a C:N:P ratio of 100:12.8:0.24. The RDX and HMX explosives flowed through the pilot unit essentially unchanged. The TNT photolyzed in the influent tank. The only effect this explosive had on the RBC operations was to color the growth on the first disc a pink color. The added phosphate in the influent had a dramatic effect on the growth of microorganisms in the first chamber. This growth became more luxuriant and new growth of the same type appeared on the discs in the second chamber. The percentage COD and BOD reduction also began to rise.

The ammonium nitrate, phosphate, sludge drip into chamber 3 was tried again on 17 July. No significant new growth appeared in chambers 3 and 4. The effluent, however, had nitrate levels up to 14 ppm on 19 July. Thus, no organisms were present which could utilize the remaining nitrates as a nitrogen source. After the drip was discontinued, nitrate levels in the effluent fell to their normal 1-2 ppm.

2. Elimination of Heavy Microbial Growth and pH Fall in the Feed Tank

On 11 July, heavy growth was observed in the influent tank. This growth caused a reduction in the BOD to the RBC. It also caused flow problems. The growth would clog lines slowing the hydraulic loading to the RBC. When the clog broke free, the loading to the RBC would increase. In

order to prevent the heavy microbial growth in the influent tanks, they were disinfected with 2 gallons of Chlorox before each new batch of feed was prepared. This procedure slowed down the growth but did not prevent it. This problem was eventually solved by placing a small tank with a pH controller in the influent line on 15 August. Once the pH controller was operating properly, the pH of the influent remained constant. The feed tank was then at its natural low pH (≤ 5), thus preventing microbial growth.

3. Evaluation of Erratic Analytical Results

During the month of July, daily swings in the COD analytical results were observed. Problems with the BOD analysis were also observed. All of the analyses were run on settled samples. However floating solids and floc were often impossible to avoid in the COD of BOD samples. The presence of these particles or floc lead to wide variations in the analytical results during one day as well as day-to-day variations. In order to solve this problem, the COD and BOD samples were filtered through a 0.45μ Millipore filter prior to analysis. This procedure was initiated on 27 July. Thus, all the analyses after this date are soluble BOD's and COD's.

4. Effects of Low Dissolved Oxygen Levels in Chamber 1

During the period of 7-9 August, very high percentages of COD and BOD reduction were achieved. The influent flow rate was 450 gal. per day or a hydraulic loading of 0.268 gallons/sq. ft./day. It appeared that the pilot unit had reached steady-state operations in the series mode. However, on 11 August, the COD and BOD removal rates began to drop. The nitrate concentrations in the effluent increased from 1-2 ppm level to 70 ppm on 10 August. Concurrently, the dissolved oxygen levels in chamber 1 fell below 1 ppm ([1]). The color of the microbial growth in chamber 1 changed from pinkish to grey indicating the presence of nitrifying bacteria in the RBC. These bacteria were detrimental to the operation of the RBC. The influent flow rate was slowed from 450 gal per day to 420 gal. per day (0.25 gallons/sq. ft/day) on 11 August. With this decrease in loading, the dissolved oxygen concentrations in chamber 1 rose to above 1 ppm. The grey microbial growth sloughed off the chamber 1 discs and was slowly replaced by the pinkish aerobic fungus observed earlier. On 16 August, hydraulic loading was again raised to 0.268 gallons/sq. ft./day and the rotational speed of this disc was increased from 2.5 to 5.0 rpm. The purpose of the increase in rotational speed was to determine if sufficient dissolved oxygen could be pumped into the liquid to sustain the microbial degradation at the higher hydraulic loading rate. Although the increase in rotational speed provided some help in this area, it did not completely solve the problem.

([1]) The dissolved oxygen levels measured during the month of August were performed with an old uncalibrated probe. Thus, levels measured were not accurate but they did show trends in the dissolved oxygen content of the water.

The maximum BOD loading obtained in the RBC series operation was 2.54 lb BOD/day/1000 sq. ft. This limitation was due to the low dissolved oxygen concentration in chamber 1. The dissolved oxygen concentration could be raised by increasing the rotation of the RBC or by addition of oxygen to the first chamber. An alternative solution was to spread the high organic loadings experienced in the first chamber over two chambers by feeding chambers 1 and 2 simultaneously. Thus the first two chambers effectively became one chamber with 840 sq. ft. of disc area instead of 420 sq. ft. This mode of operation was designated 2-1-1 and was initiated on 20 August.

In general the 2-1-1 mode operated very well. The BOD reduction returned to the 90-100% range and remained there except for periods of pump failure and intentional increases in flow rates. However, COD reduction only averaged between 78 and 88%. The COD reduction in the 90-95% range observed for a brief time during the series operation could not be obtained at the 450 to 576 gal. per day flow rates utilized during the 2-1-1 operation. Dissolved oxygen concentrations in chambers 1 and 2 were also a problem in the 2-1-1 operation. Even with an increased rotational speed of the RBC from 2.5 rpm to 5 rpm, the dissolved oxygen concentrations often fell below 1 ppm during the hot days in August and early September.

During the month of September and part of October, problems were encountered in the BOD analyses. Other wastewater samples were being analyzed at this time. These samples were found to contain large amounts of sulphur compounds. These samples reduced the sensitivity of the dissolved oxygen probe. The result was a decrease in the apparent BOD concentrations especially at the higher levels. The probe was replaced on 17 October.

B. Pilot Unit Operations on the "B" Wastewater

On 17 September, the "B" wastewater was fed to the RBC pilot unit. The influent flow rate was reduced to 200 gal per day in order to maintain the BOD loading less than 2.7 lb BOD/1000 sq. ft./day. The sequence of events and observed COD and BOD reductions for ∿2 months of pilot operation on the "B" wastewater are presented in Figure 7. The day-to-day operational parameters are presented in Appendix B.

The initial feed solution was over neutralized by mistake to a pH of 11. This solution was back titrated with acetic acid to a pH of ∿7. Thus, the first week of operation on the "B" wastewater had excess acetic acid and the initial COD values of 2600 ppm were higher than those normally observed for the "B" wastewater. BOD levels were ∿50% of the COD values, however, due to problems with the dissolved oxygen probe described earlier, these values are too low and should be approximately equal to the COD values.

Observed COD values of the "B" wastewater were between 1800 and 2200 ppm in warm weather. When the temperature dropped below 18°C, the observed COD values increased to 2800 - 2900 ppm due to less volatilization of the organics such as cyclohexanone and toluene.

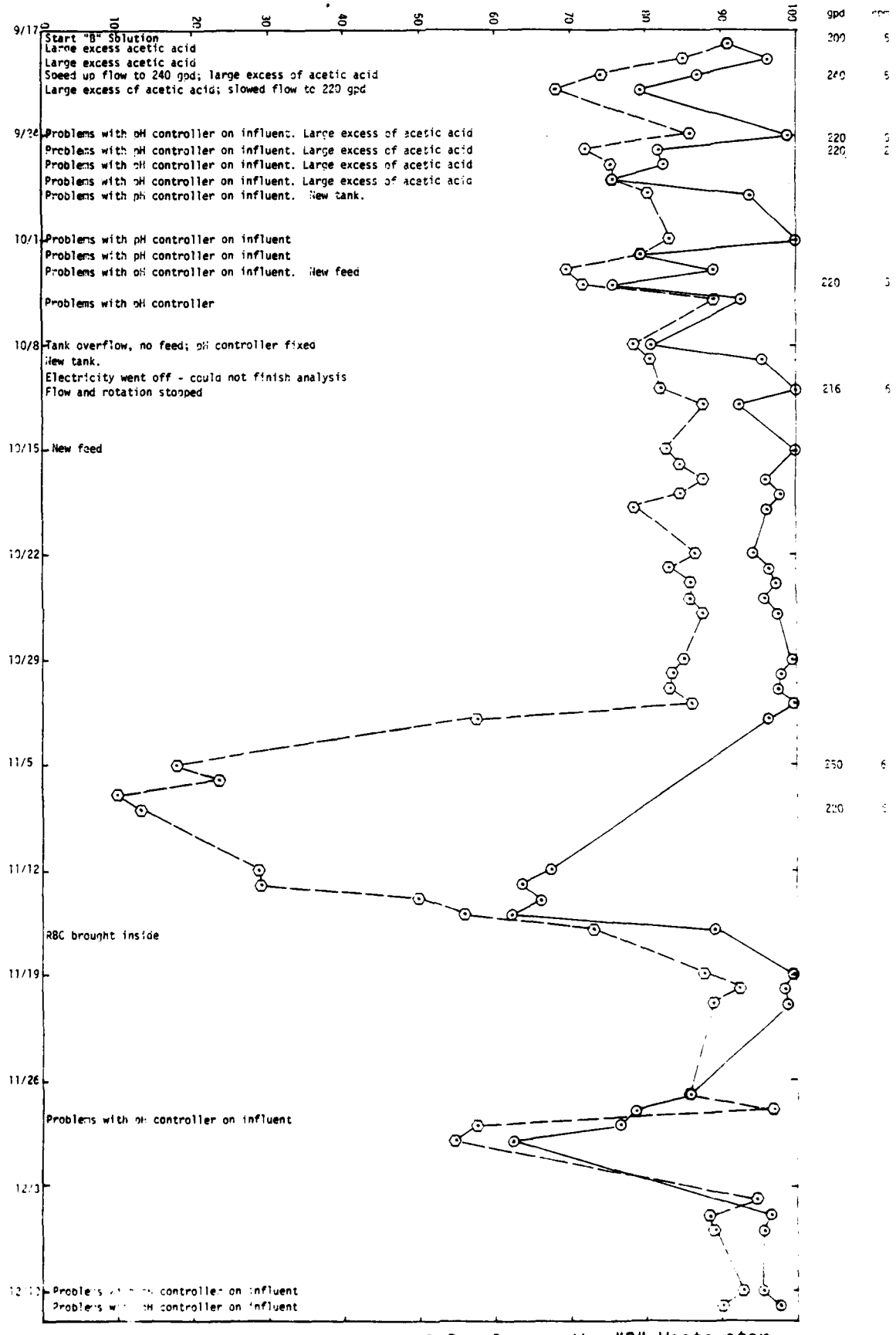


Figure 7. RBC Operational Results on the "B" Wastewater

After a period of flow adjustments and pH controller problems, steady state operation was obtained with soluble COD reductions averaging between 80 and 86% and soluble BOD reductions between 95 and 100% at flows of ~220 gal. per day on 2 November, the temperatures fell below 10°C (50°F) and remained low for several days. The BOD and COD reduction efficiency dropped severely. The microorganisms on the discs sloughed off. The RBC unit was moved indoors on 14 November. The RBC organisms recovered within 7 days and the percentage COD and BOD reductions returned to the 80-85% and 95-100% levels, respectively. The pilot unit operation was continued to 26 December with periodic sampling.

IV. RESULTS OF THE PILOT SCALE EVALUATION OF THE SITE "X" WASTEWATERS

A. Comparison of Calculated to Actual Wastewater Parameters

In the original analysis of the streams entering the site "X" wastewater treatment plant, COD, BOD, TOC, TSS, TDS, alkalinity and pH were estimated. These estimates were as follows for the total dry weather wastewater (see Table 1):

pH	5.5 - 7.3
alkalinity	142
BOD	198
COD	286
TOX	53
TKN	34
TSS	144
TDS	419

With these values, the wastewater would have general characteristics very similar to domestic wastewaters. However, when the synthetic wastewater was formulated for the bench and pilot plant operations, many of these parameters were found to be in error. The observed experimental parameters for the "A" and "B" wastewaters are presented in Table 6.

The pH of the synthetic wastewater was lower than expected with actual values between 3 and 4 instead of the 5.5-7.3 anticipated value. As a result of the low pH, no alkalinity was present in the unneutralized feed stream. However, the most important discrepancies were in the COD, BOD, TOC and TSS values. The experimental values of these parameters were found to be significantly higher than the anticipated values.

In order to confirm if the numbers determined experimentally were realistic, the soluble BOD and COD values were calculated. Several assumptions were made for this calculation.

- the water insoluble chemicals, *e.g.* toluene, stearic acid, will not contribute to the soluble BOD and COD values

Table 6.. Parametric Analysis of "A" and "B" Wastewaters

Average "A" Wastewater		Fresh	Average "B" Wastewater
SCOD	1242	1366	2127
TCOD	1461	1609	2473
$\frac{SCOD}{TCOD}$	0.85	0.85	0.86
SBOD	1187	1306	*
TBOD	1374	1519	*
$\frac{SBOD}{TBOD}$	0.86	86	*
$\frac{SBOD}{SCOD}$	0.956	.956	*

* Not determined due to problems with the dissolved oxygen probe. Outside analyses indicate a SBOD/SCOD ratio of 0.98 and a SBOD/TBOD ratio of 0.86.

- significant losses of the high vapor pressure organics will occur, *i.e.* 50% loss of cyclohexanone, 20% loss of acetone, 20% loss of 1-propanol, 20% loss of methyl acetate, 50% loss of n-propyl acetate

- hexamine will react to form ammonia and formaldehyde

- no siginficant losses of acetic, formic acid or formaldehyde will be experienced

- the explosives will not contribute significantly to the BOD or COD.

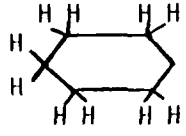
Based on these assumptions, soluble COD values were calculated as shown in Table 7. A soluble COD value of 1529 ppm was calculated for the "A" stream and 2370 for the "B" stream.

Average soluble COD (SCOD) values were then calculated from the experimental data obtained on the "A" and "B" wastewaters. For the "A" wastewaters, the average SCOD value was 1242 ppm (days where large amounts of growth in the feed were eliminated from the calculations). SCOD values within 24 hours of feed preparation averaged 1366 ppm. Thus, significant losses of material were observed from either evaporation or microbial degradation when the influent was allowed to stand for several days. The average SCOD value determined experimentally on the "B" wastewaters was 2127 ppm during cool weather or ~1.55 times that observed for the "A" stream new tank. During colder weather, the SCOD values observed in the influent were significantly higher due to less volatilization and microbial action. The SCOD values calculated for the "A" and "B" streams (Table 7) are in fair agreement with the average values determined experimentally.

Since most of the hard to degrade chemicals, *e.g.* toluene, are lost through volatilization leaving short chain molecules, the SBOD values should be approximately equal to the SCOD values. For the "A" stream, SBOD averaged 95.6% of the SCOD. On the "B" stream, the absolute magnitude of the influent SBOD values are questionable because of D.O. probe problems. However, outside analyses performed by Autotrol confirmed that the SBOD were 95-100% of SCOD values.

Total organic carbon (soluble) values were calculated for the "A" and "B" streams. The calculated values were 580 ppm and 899 ppm, respectively. No TOC were run on the "A" stream due to problems with the carbon analyzer. The average TOC value for the "B" was 896 which is in excellent agreement with the calculated value.

Table 7. Calculated SCOD Values for the Site "X" Wastewaters

Reaction	"A" Wastewater Concentration, ppm	Calculated COD, ppm
$H_2CO + O_2 \rightarrow CO_2 + H_2O$	670	719
$HCOOH + \frac{1}{2}O_2 \rightarrow CO_2 + H_2O$	218	76
$H_3C\text{-}C(=O)\text{-}OH + 2O_2 \rightarrow 2CO_2 + 2H_2O$	82	87.5
$CH_3\text{-}C(=O)\text{-}CH_3 + 4O_2 \rightarrow 3CO_2 + 3H_2O$	54	119 x .8 = 95.3
$CH_3\text{-}O\text{-}C(=O)\text{-}CH_3 + 3\frac{1}{2}\ O_2 \rightarrow 3CO_2 + 3H_2O$	24	36.6 x .8 = 29.1
$CH_3CH_2CH_2OH + 4\frac{1}{2}\ O_2 \rightarrow 3CO_2 + 4H_2O$	63	153.6 x .8 = 122.9
$CH_3\text{-}C(=O)\text{-}O\text{-}C(=O)\text{-}CH_3 + 4O_2 \rightarrow 4CO_2 + 3H_2O$	31	38.9
$CH_3CH_2CH_2\text{-}O\text{-}C(=O)\text{-}CH_3 + 6\frac{1}{2}\ O_2 \rightarrow 5CO_2 + 5H_2O$	7	14.3 x .5 = 7.2
Hexamine $\rightarrow 6CH_2O + 6NH_3 \rightarrow 6CO_2 + 6H_2O + 6NH_3$	45	288
 $= O + 8O_2 \rightarrow 6CO_2 + 5H_2O$	113	130.6 x .5 = 65.3

Total SCOD for "A" Wastewater 1529 ppm

Total SCOD for "B" Wastewater 2370 ppm

B. Identification of Microorganisms in the RBC Unit

Identification of the microorganisms in the RBC unit was attempted by the methods described in Section IIG. The data on the identification of the bacterial isolates from the first and third chambers and the RBC effluent are presented in Table 8. All but one of the 15 bacteria isolates were motile gram-negative rods. All but two of the isolates were oxidase positive. Since pseudomonads are the only common gram-negative rods that are oxidase positive, all but the spore forming rod (D-3) appeared to be different strains of pseudomonads. In addition, nine of the isolates formed blue fluorescent pigments similar to that formed by *Pseudomonas fluorescens*.

Many isolates of filamentous organisms were made. One type always predominated, and no other was consistently recovered although many common molds passed through. The filamentous organisms grew rapidly on several common media with a yeast smell and formed white colonies without any characteristic structures. This fungus laid down cross walls and broke up into arthrospores which were ovoid in shape as shown in Figure 8. Thus, it appears to be a dimorphic organism with coexistent and interchangeable yeast and mycelial stages. The fungus appears to resemble the genus *Geotrichum* although more work is necessary for positive identifications.

C. Loading Parameters for the Pilot RBC Unit

The SCOD loadings versus percent SCOD and SBOD reductions for the "A" and "B" streams are plotted in Figures 9 and 10. Because of the unreliability of some of the SBOD data, SCOD values were used to determine the loading on the RBC unit. Since the influent SCOD$\approx$SBOD, the use of SCOD instead of SBOD is valid in this case. The points plotted are averages for several days of operations under the loading conditions. Two curves were obtained for the SCOD loading of the "A" and "B" streams instead of the expected single curve. The difference in the SCOD loadings versus reduction of the two streams is due to the temperatures. The "A" stream was run during the summer months when temperatures were above 22°C (74.6°F). In contrast, the "B" stream performance data were collected during late September, October and November. The average temperatures during this period were less than 12°C (54°F). As can be observed from Figure 11, temperatures below 13°C (55.4°F) begin to have a noticeable effect on the reduction efficiency. At temperatures below 10°C (50°F), the RBC operations become very inefficient.

The loadings on each stage and percent reductions for the series and 2-1-1 operations on the "A" streams are presented in Table 9. Both modes of operation work efficiently. The 2-1-1 operation is more resistant to shocks and less dissolved oxygen limited. However, in either case, the system is dissolved oxygen limited at loadings greater than 2.54 lb SCOD or SBOD/1000 sq. ft./day. These SBOD or SCOD are the maximum that can be maintained with good reduction efficiency.

Table 8. Identification of Bacteria in the RBC Pilot Unit

BIODISC BACTERIA

Fluorescent	Eugon Agar Colonial Morphology Size	Color	3 days Growth in Oxoid #2 Broth	Growth in TSB	Acid from Glucose	Gram Stan Morphology Morphology	Motility	Litmus Milk - 2 days	Litmus Milk - 4 days	Oxidas Test
D-1	4 mm	Glossy Beige	+	+ + Pellicle	+	G-RODS	+	Blue top White butt	White with BLUE TOP RING	+
D-2	7½ mm	Glossy Beige	+ + ½	+ + + +	+	G-RODS, like D-1	+	like D-1	like D-1 more blue vol.	+
D-5	4 mm	Glossy Beige	+	+ + + Pellicle	+	G-RODS, like D-1	+	like D-1	like D-1	+
BD-1	4 mm	Glossy Creamy Beige	+	+ + Pellicle	+	G-RODS	+	like D-1	like D-1	+
BD-2	4 mm	Glossy Beige	+	+ + + Pellicle	+	G-RODS, shorter than D-1	+	like D-1	like D-1	+
BD-5	4 mm	Glossy Beige	+	+ + + Pellicle	Weak +	G-RODS, short, chains	+	like D-1	like D-1	weak
BD-6	3.5 mm	Glossy Yellow-tan	+ +	+ + + +	+	G-RODS, like D-1	+	like D-1	like D-1	+
BD-7	3 mm	Glossy Beige	+ + +	+ + + + Pellicle	+	G-RODS, small short	+	like D-1	like D-1	+
BD-9	5 mm	Sectored Beige	+ + +	+ + + +	+	G-RODS, coccobacillary like D-4	+	like D-1	like D-1	+
Non-Fluorescent										
D-3	6 mm	Dry Creamy	+	± very slow floc	+; gal ±	G+RODS, HUGE!	Not observed	Pink top White butt	color like the control; all pink/white	
D-4	2 mm	Glossy Pale Yellow	±	± slow floc		G-RODS, caccobacillary like BD-9	+	Pink top White butt	all White	weak +
BD-3	4 mm	Rough Cream	+ +	+ + + + Pellicle		G-RODS, THINNER than others, chains	+	Purple top CASEIN DIGESTED	Pellicle & more digestion	
BD-4a	4 mm	Glossy Creamy	+ +	+ + + +	+	G-RODS, like D-1, but no short rods	+	like D-1	like D-1	+
BD-4b	1.5 mm	Glossy Yellow	+	+ + + +	+	G-RODS, similar to BD-4a, very uniform	+	like D-1	thin, pale blue volume	weak +
BD-8	4 mm	Glossy Beige	+ + ½	+ + + +	slow +	G-RODS, short to long, like D-1	+	like D-1	like D-1	+

D-1 D-5 BD: 1, 2, 5 & 7 are similar

Other Gram negative rods that may be pseudomonads are BD: 3, 6, 8 and 9

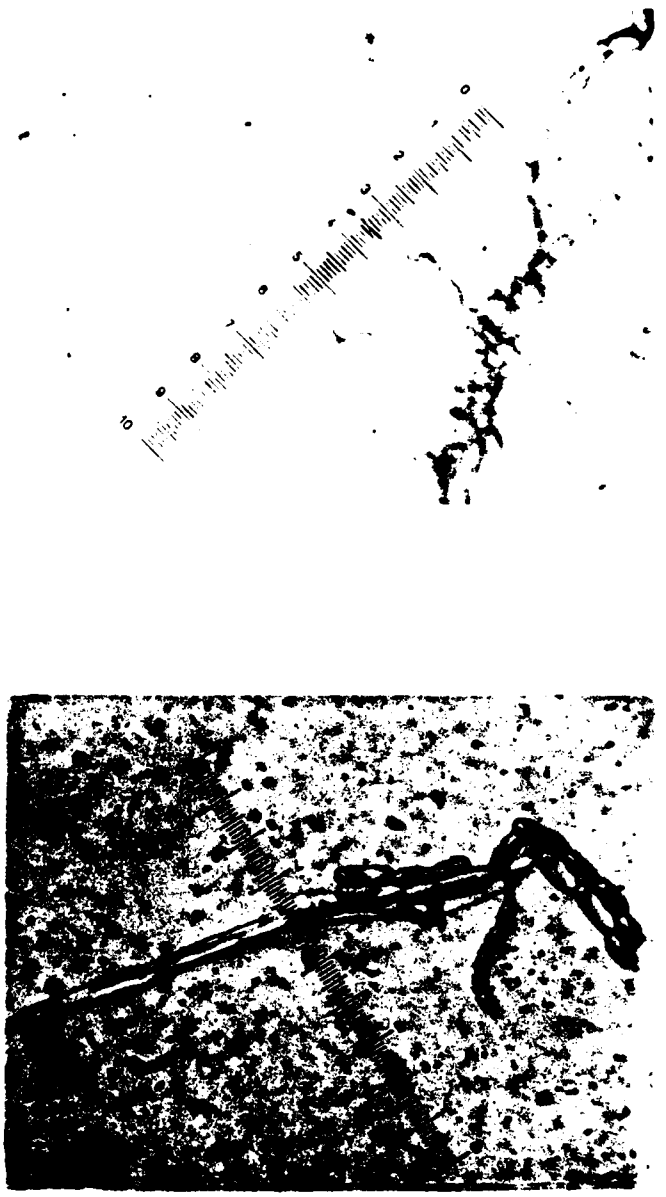


Figure 8. Photographs of RBC Fungal Organism

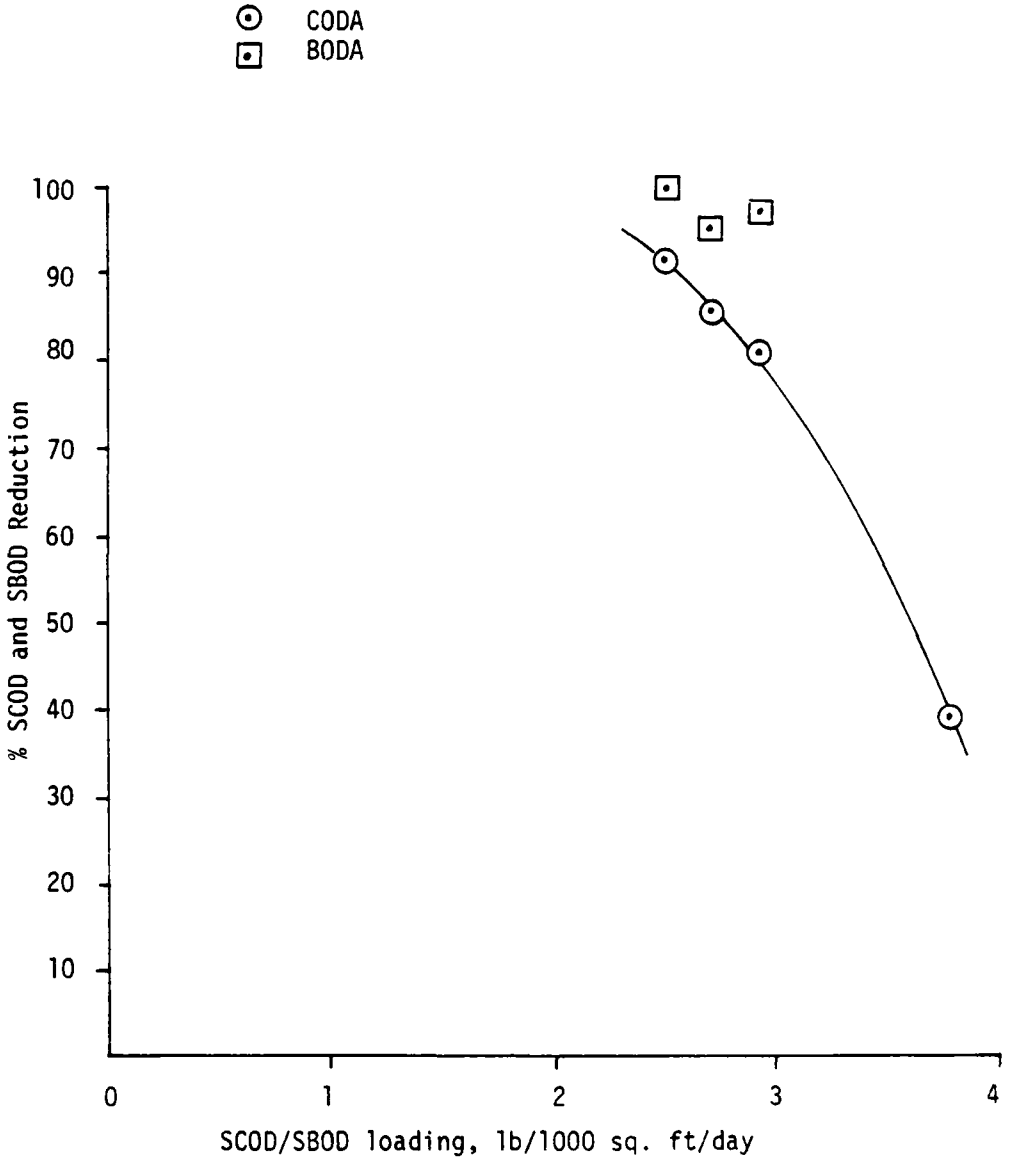


Figure 9. Loading Parameters for RBC Pilot Unit - "A" Stream

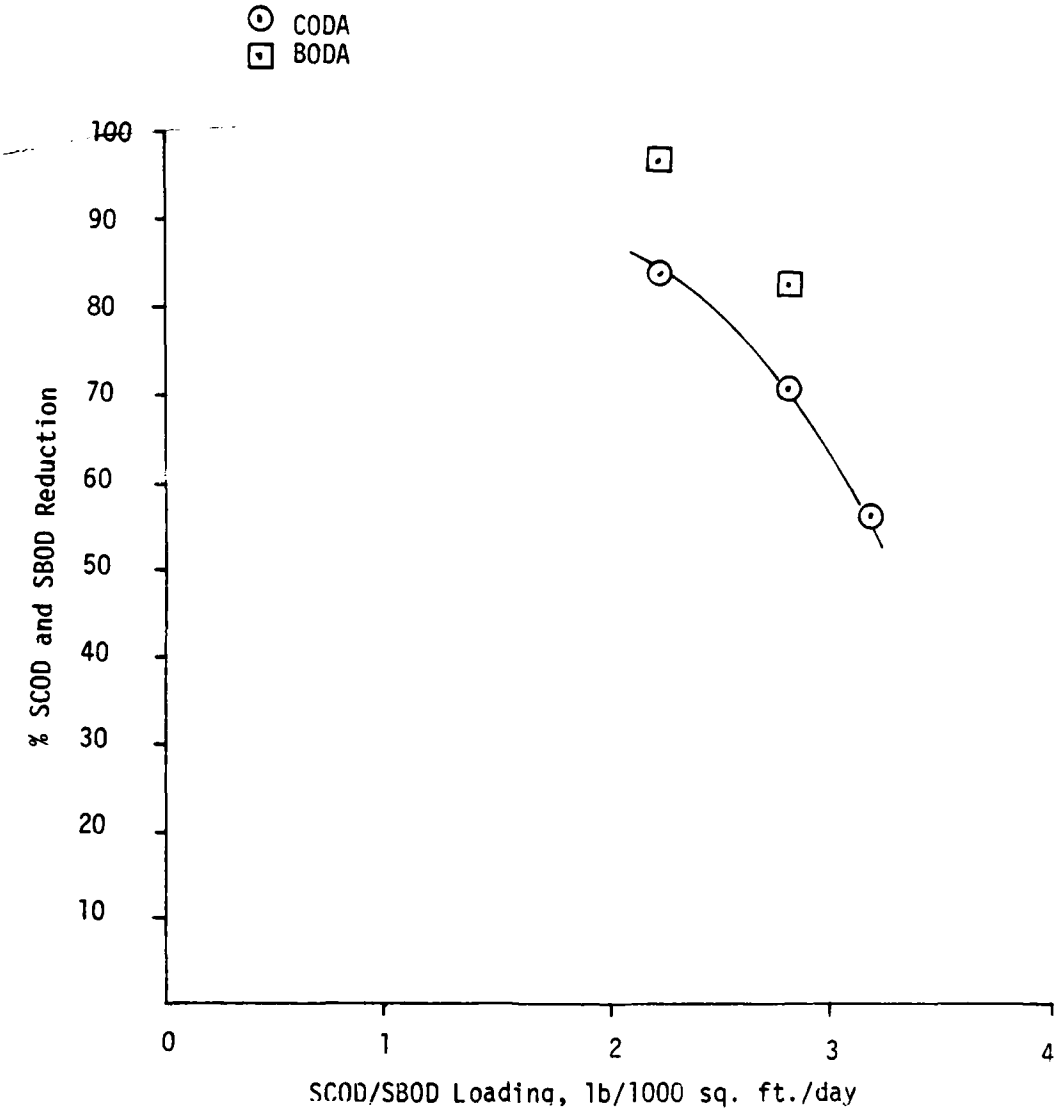


Figure 10. Loading Parameters for RBC Pilot Unit - "B" Stream

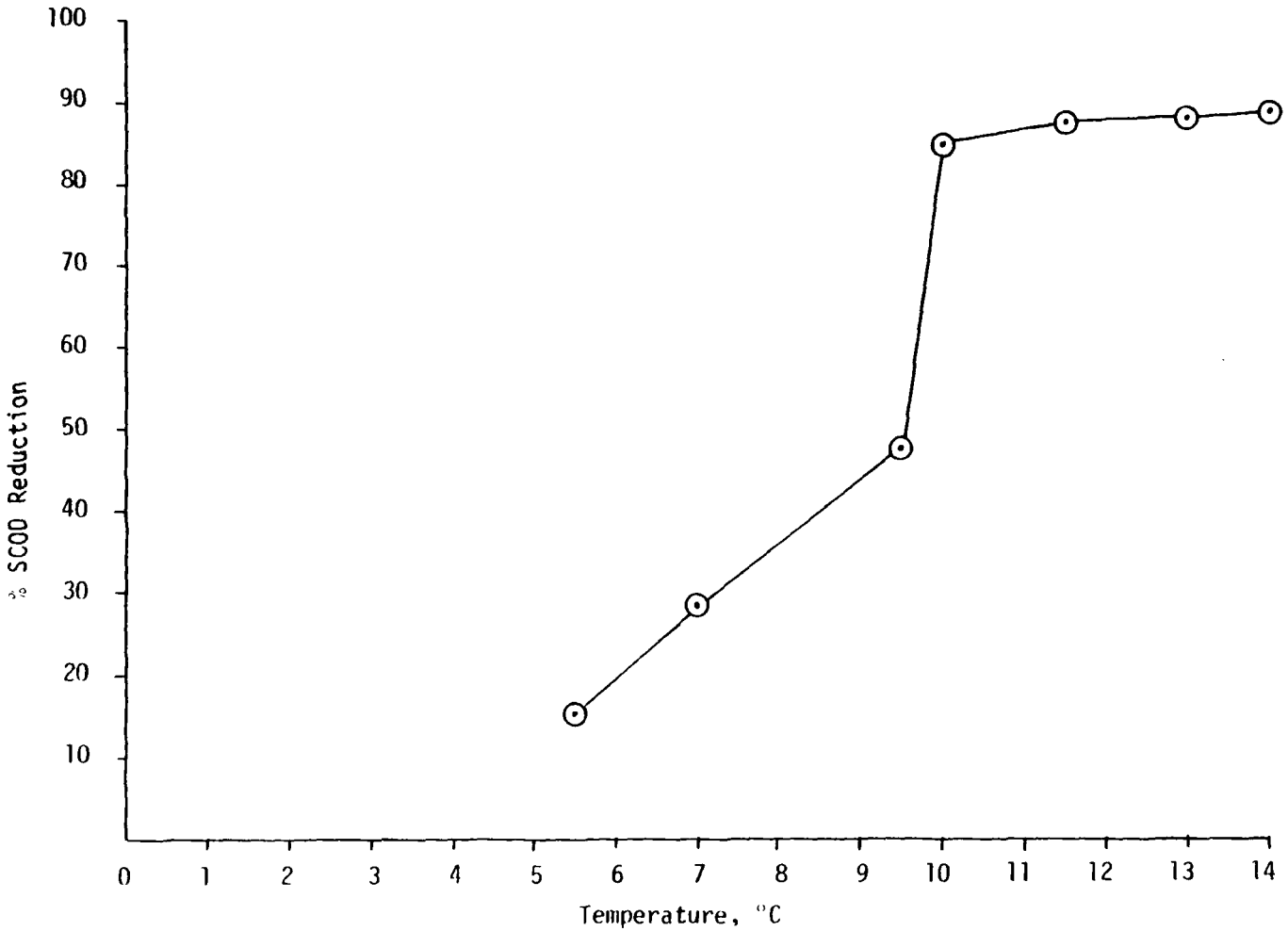


Figure 11. Effect of Temperature on Pilot RBC Unit Performance (Based on Soluble COD Reduction)

Table 9. Comparison of Loading Parameters for Series and 2-1-1 Operational Modes

		7 August	8 August	9 August	8 September	9 September	10 September
Chamber 1	BOD Loading lb/ 1000 sq. ft./day	-	10.08	10.44	-	-	-
	BOD Removal	-	66.2%	56.8%	-	-	-
	COD Loading lb/ 1000 sq. ft./day	11.53	9.5	9.88	5.22	5.53	6.10
	COD Removal	50.5%	46.4%	57.3%	74.5%	74.7%	7.14%
	BOD/COD	-	1.06	1.06	-	-	-
Chamber 2	BOD Loading lb/ 1000 sq. ft./day	-	3.41	4.22	-	-	-
	BOD Removal	-	82.5%	72.3%	-	-	-
	COD Loading lb/ 1000 sq. ft./day	5.71	5.10	4.22	-	-	-
	COD Removal	45%	36%	70%	-	-	-
	BOD/COD	-	.668	1.07	-	-	-
Chamber 3	BOD Loading lb/ 1000 sq. ft./day	-	0.60 lb/day	1.25	-	-	-
	BOD Removal	-	100%	35.4%	-	-	-
	COD Loading lb/ 1000 sq. ft./day	3.12	3.25	1.35	2.66	2.80	3.49
	COD Removal	64.3%	52%	30.3%	15.7%	28.5%	28.8%
	BOD/COD	-	.184	.926	-	-	-
Chamber 4	BOD Loading lb/ 1000 sq. ft./day	-	0	0.81	-	-	-
	BOD Removal	-	0	100%	-	-	-
	COD Loading lb/ 1000 sq. ft./day	1.11	1.56	0.94	2.24	2.00	2.49
	COD Removal	12.8%	47.4%	15.1%	30.1%	22.7%	39.3%
	BOD/COD	-	-	.151	-	-	-
Effluent	Total BOD Removal	-	100%	100%	-	-	-
	Total COD Removal	91.6%	91.4%	94.9%	85.0%	86.0%	87.6%
	Residual COD	109 ppm	92 ppm	90 ppm	165 ppm	163 ppm	159 ppm

- Not determined

The microorganisms in the RBC were unique in that only two main species of organisms were present. These organisms were present throughout the RBC unit. Early in the program, it was not known if a culture of limited species such as was observed in the RBC unit could tolerate shocks. Two types of shock loadings were investigated - BOD/COD shocks and variations in pH of influent. Data indicate (see Appendix A and B) the variations in the BOD loading is tolerated by the organisms. However, two potential problems were observed:

(1) The shock loading cannot go above 2.5 lb BOD/ 1000 sq. ft./day because dissolved oxygen limitations

(2) A large decrease in BOD loading causes significant die off of the organisms and 1 to 2 days are required to return the RBC to peak efficiency when BOD loading is again returned to normal.

Variations in the pH of the influent over a range of 5 to 10 are tolerated by the microorganisms with some loss of degradation efficiency. Influent pH in the 7-8.5 range resulted in the greatest overall efficiency and is thus the preferred pH range.

D. Expected RBC Effluent Parameters

Soluble COD reductions between 85 and 92% are obtained during optimum performance of the RBC unit (SBOD loading of <2.5 lb/100 sq. ft./day). Soluble BOD reductions for the optimum performance correspond to a 95 to 100% reduction. Thus, for the two stream residual SCOD and SBOD levels will be:

	"A" Stream Residuals	"B" Stream Residuals
SCOD	99 - 186 ppm	170 - 319
SBOD	0 - 59 ppm	0 - 104 ppm

Total BOD and COD values will be higher than the soluble values since the RBC only works on SBOD and SCOD. Insoluble BOD and COD values in the "A" influent were 230 ppm and 241 ppm, respectively. In the "B" influent, the insoluble BOD and COD values were ∿346 ppm and 339 ppm. These values plus the soluble parameters yield the maximum TBOD and TCOD values expected. These maximum effluent values would be:

	"A" Stream Residuals	"B" Stream Residuals
max TCOD	346 - 427 ppm	516 - 665 ppm
max TBOD	230 - 289 ppm	339 - 443 ppm

The amount of TBOD and TCOD actually leaving the full-scale plant will thus depend on the efficiency of the RBC and the efficiency of pre and post filtration in removing the components, *i.e.* stearic acid and other insoluble organics, which contribute to the insoluble BOD and COD in the streams.

Spot ammonia analyses were performed by first distilling the ammonia from the solution to remove formaldehyde interferences. The distilled ammonia was determined by an ammonia electrode. These tests showed no detectable ammonia after the third chamber. Thus, the effluent ammonia levels can be controlled by regulating the addition of ammonia to the feed stream.

E. Toxicity of RBC Influent and Effluents to the Bluegill Sunfish

The LC50 for 24, 48 and 96-hour exposure of bluegill sunfish (*Lepomis macrochirus*) to the RBC influent, effluents and granular activated carbon filtrate are presented in Table 10. The water parameters for the test solutions are given in Table 11. The influent "B" stream was highly toxic to the bluegill sunfish with LC50 values between 1.0 and 1.5 volume/volume percent (% v/v) depending on the length of exposure. The toxicity of the RBC effluent ("B" stream) was much lower than the influent, with a 24-hour LC50 of 46.5% (v/v). The toxicity test of the effluent "B" stream was repeated on 12 October 1979 with similar results.

The effects of the "B" stream RBC effluent, containing no TNT in the feed, was also examined. The LC50 of the "B" stream effluent (no TNT was in influent) 37% v/v. This LC50 was similar to the value for the RBC effluent with TNT. These tests indicate that TNT and its transformation products are not the primary cause of the acute toxicity of the wastewater to the bluegill sunfish.

The toxicity of the "B" stream effluent appeared to be independent of the BOD reduction. This could be due to several factors:

- high salt levels
- residual toxic materials not removed by the RBC microorganisms
- biotransformation of an influent constituent into a highly toxic recalcitrant material

The toxicity of the carbon effluent was highly dependent on the length of time exposed to the carbon. The RBC effluent filtered through 2 feet of Filtersorb 400 had a 24-hour LC50 of 45%. RBC effluent filter through 6 feet of Filtersorb 400 had a 24-hour LC50 of greater than 60%. Thus, the carbon can remove a significant amount of the toxic material, however, it is not very efficient.

The toxicity of the "A" stream RBC effluent was significantly less than that observed for the "B" stream. The "A" stream has a concentration of approximately 0.645 that of the "B" stream. However, the 24-hour aquatic toxicity of the "A" stream was less than 0.55 times that observed with "B" stream. Effluent components of the "B" stream need to be identified to determine why the "B" stream is more toxic than would be predicted from the "A" stream results.

Table 10. Toxicity of RBC Influent and Effluents to the Bluegill Sunfish (*Lepmmis macrochirus*)

	Hours	LC50 Mixture in % v/v	95% Confidence Range in % v/v
Influent "B" Stream 4 October 1970	24	1.5	1.0-2.1
	48	1.3	0.8-1.9
	96	1.0	0.6-1.8
Effluent "B" Stream 4 October and 12 October 1979	24	46.5	39-56
Effluent "B" Stream (No TNT) 11 December, 1979	24	37.0	29-47
Effluent "B" Stream 14 December, 1979	24	45% death at 85%	-
	48	74.0	51-100
Carbon Filtrate, 2 Feet 1 November, 1979	24	55.0	43-70
Carbon Filtrate, 6 Feet 2 November 1979	24	30% death at 60%	-
	48	30% death at 60%	-

Table 11. Stream Parameters for Aquatic Toxicity Tests

	"B" Stream Influent 4 October 1979	"B" Stream Effluent 4 October 1979	"B" Stream Effluent 12 October 1979	"B" Stream Carbon Filtrate 1 November 1979	"B" Stream Effluent (No TNT) 11 December 1979	"A" Stream Effluent 14 December 1979
pH	8.35	8.75	8.5	8.0	8.65	8.1
D.O.*	8.8 ppm	13	10.0	9.2	8.0	>8.0 ppm
Alkalinity	108 ppm	588 ppm	422	310 ppm	1162 ppm	-
Nitrate-N	-	1 ppm	2 ppm	-	1.2 ppm	1.0 ppm
COD	1868 ppm	529 ppm	266 ppm	18 ppm	229 ppm	374 ppm
BOD	1274 ppm*	305 ppm	143 ppm	-	41 ppm	20 ppm
Formaldehyde	1340 ppm	33 ppm	40 ppm	-	33 ppm	-
RDX	>10	>10	6.5 ppm	-	-	-
HMX	0.6 ppm	0.6 ppm	0.3 ppm	-	-	-
TNT	1.6 ppm	BDL	0.6 ppm	-	0	-

* Values lower than actual due to insensitivity of the dissolved oxygen probe.

BDL - below detection limit of approximately 0.1 ppm

\- not measured

The treatment of the munition wastewater stream by the RBC significantly reduced the toxicity of the stream. The carbon filtration of the RBC effluent also reduced the toxicity, although a large amount of activated carbon is required. The removal of TNT from the wastewater stream did not substantially change the toxicity of the effluent.

F. Mutagenicity Testing on the RBC Effluent and Carbon Filtrate

The results of the Ames test on the "B" stream effluent from the pilot RBC collected on 4 October and the carbon column effluent collected on 1 November 1979 are presented in Table 12. Analyses of the samples are presented in Table 13. Photographs of the test plates are shown in Figure 12. Clear evidence of mutagenic activity was indicated only when the test sample showed >10X the number of revertants found in the negative controls. When the samples were added to paper discs, revertant colonies were observed clustered around the discs. Mutagenicity in the RBC samples was clearly indicated by all tester strains, indicating the presence of multiple mutagens working by different mechanisms. No activation was needed to produce this mutagenicity. The carbon effluent samples were not clearly mutagenic under the test condition. The carbon effluent samples were filtered through 6 ft. of fresh Filtersorb 400. Older carbon may allow more of the mutagenic components of the effluent to pass through.

Further tests were conducted to evaluate the effect of TNT in the influent on the RBC effluent mutagenicity. A sample of the Ft. Belvoir bench scale RBC effluent ("A" solution - no explosives) and of Iowa pink water were tested. As shown in Table 14, these samples with and without metabolic activation did not give any clear evidence of mutagenicity. The pink water was toxic to the *Salmonella* tester strains, as indicated by a zone of cellular inhibition. The number of revertants was within allowable variation from the negative controls. Testing of these samples were repeated along with samples from ARC RBC influent ("B" solution, no TNT), RBC effluent and carbon filtrate collected on 21 November 1979. Analysis of these samples are given in Table 15. As can be observed from Table 15, no clear evidence of mutagenicity was found.

G. Solids Concentrations in the RBC Effluent and Settling Test Results

Average concentration of total solids (TS), total suspended solids (TSS) and total volatile solids (TVS) in the RBC effluent are given below:

	"A" Stream	"B" Stream
TSS	150.3 ppm	132 ppm
TVS	297 ppm	473 ppm
TS	597 ppm	1042 ppm

Table 12. Ames Spot Test Results on ARC RBC Samples of "B" Stream Collected on 1 November 1979 (No S9 Activation)

Tester Strain	Negative Controls	Samples on Paper Disc		Positive Controls		
		RBC	CCF	MNNG 2 µg/plate	9AA 10 µg/plate	2AF + S9 10 µg/plate
TA 100	26	TNTC	19	TNTC	TNTC	TNTC
TA 98	20	TNTC	30			TNTC
TA 100	190	TNTC	489	TNTC		
TA 1535	20	TNTC	30	TNTC		
TA 1535	18	TNTC	48	TNTC		
TA 1537	8	TNTC	12		TNTC	
TA 1537	8	TNTC	8		TNTC	

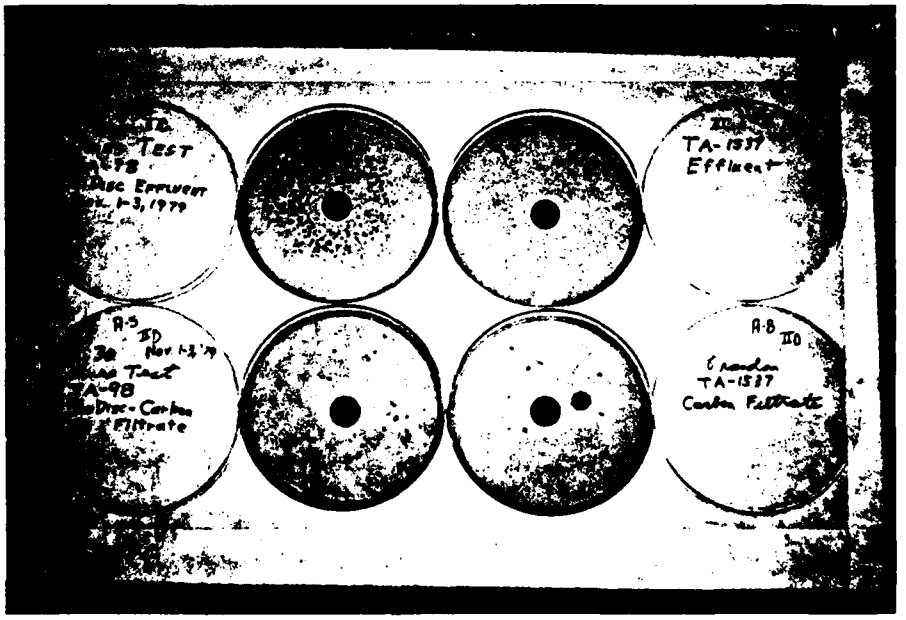
RBC: ARC Biodisc Effluent
CCF: Column Carbon Filtrate
TNTC: Too Numerous to Count >500 revertant per plate
MNNG: N-methyl-N'-nitro-N-nitrosoguanidine
9AA: 9-aminoacridine
2AF: 2-aminofluorene

Table 13. Stream Analyses for Ames Testing

	"B" Stream Effluent 1 November	"B" Stream Carbon Filtrate 1 November	"B" Stream Influent No TNT 21 November	"B" Stream R3C Effluent No TNT 21 November	"B" Stream Carbon Filtrate No TNT 21 November
pH	8.0	-	6.2	8.6	8.0
D.O.	10.4	-	8.8 ppm	8.7 ppm	-
Alkalinity	26 ppm	310	48 ppm	546 ppm	552 ppm
Nitrate	2 ppm	1 ppm	-	3 ppm	-
COD	296 ppm	18 ppm	1811 ppm	200 ppm	283 ppm
BOD	8 ppm		1406 ppm	15 ppm	-
Formaldehyde	29 ppm		850 ppm	26 ppm	-
RDX	>10 ppm	-	-	-	-
HMX	0.8 ppm	-	-	-	-
TNT	1.7 ppm		0	0	0

- not analyzed

A. Comparison of RBC "B" Effluent (1 November 1979) with Negative Controls



B. Comparison of RBC "B" Effluent (1 November 1979) with Triple Carbon Filtrate (1 November 1979

Figure 12. Photographs of Ames Test Plates

Table 14. Ames Spot Test Results on Ft. Belvoir "A" Stream (no expolsives) and Iowa Pink Water

Tester Strain	Negative Controls Plain	+S9	Ft. Belvoir RBC Effluent ("A" stream-no explosives) Plain	+S9	Iowa Pink Water Plain	+S9	Positive Controls MNNG 2 µg/ plate	2AF +S9 10 µg/ plate
TA 98	19	26	31	20	21	34		TNTC* central
TA 98	15	17	15	17	26	11		TNTC* central
TA 98	26	17	20	25	27	10		TNTC* central
TA 100	161	177	195	216	197	219	TNTC* random	TNTC* central
TA 1535	16	19	19	22	24	14	TNTC* circu- lar	

* TNTC: Too Numerous to Count
MNNG: N-methyl-N'nitro-N-nitrosoguanidine
2AF: 2-aminofluorene

All plates had 0.1 ml of test solution placed on central disc.

Table 15. Ames Spot Trest Results on Ft. Belvoir "A" Stream (no explosives) Iowa Pink Water and ARC "B" Stream (No TNT)

Tester Strain	Negative Controls		Ft. Belvoir Effluent ("A" stream-no explosives)		Iowa Pink Water		ARC RBC ("B" Stream - No TNT) 21 November 1979						Positive Controls	
							Influent		Effluent		Filtrate		MNNG 2 µg/ plate	2AF+S9 10 µg/ plate
	Plain	+S9	Plain	+S9	Plain	+S9	Plain	+S9	Plain	+S9	Plain	+S9		
TA 98	12	8	16	29	22	28	15	27	15	40	27	48		93 central
TA 100	146	121	97	124	126	142	119	209	120	188	178	144	TNTC* ring	193 random
TA 1535	13	11	10	12	12	20	19	19	11	29	9	26	TNTC* ring	
TA 1537	6	4	6	18	9	20	2	23	14	23	10	18		135 central
TA 1538	6	4	5	24	5	30	6	25	5	26	6	34		72 central

* TNTC: Too numerous to count
MNNG: N-methly-N'-nitro-N-nitrosoguanidine
2AF: 2-aminofluorene

All plates had 0.1 ml of test solution placed on central disc.

The high total solids concentrations are due primarily to salts formed during the neutralization process. The TVS and TS concentrations for the "B" stream are 1.59 and 1.75 times those observed for the "A" stream. These values are within the expected solids range since the "B" stream is ∿1.55 more concentrated than the "A" stream. Total suspended solids concentrations on the other hand do not correspond to the expected ratio nor the expected values. The expected TSS concentration can be calculated from the following equation:

$$TBOD = SBOD + K \times TSS$$

where K is a constant equal to 0.7-1.0 for industrial wastewaters (Autotrol Corporation, 1979), The SBOD/TBOD ratios for both the "A" and "B" stream are 0.85. Using this value and SBOD values of 1306 ppm for the "A" stream and 2127 ppm for the "B" stream, an expected TSS concentration can be calculated. For K = 1, the expected TSS for the "A" and "B" stream are 230 ppm and 339 ppm, respectively.

During the TSS tests conducted in the laboratory, it appeared that a significant amount of material was collected on the filter. However, after oven drying only small amounts of the material remained. Thus, it appeared that a significant portion of the TSS were volatile at the 105°C used to dry the filter. These observations support the conclusion that TSS should be ∿230 ppm for "A" and 339 for "B".

Settling tests on the RBC effluent indicated the presence of two types of suspended solids - a heavy fibrous floc composed mainly of the fungus organism growing in the RBC and a light non-settling material composed of fungus spores and undissolved chemicals. As discussed in Section IVB, the spores are a result of division of the fungal mycelium. The presence of these spores will be a problem in the design of filters for the full scale wastewater treatment facility. These spore germinate when sufficient nutrients are present. The fungal mycelium shown in Figure 5 are rapidly produced, clogging up sand and carbon filter systems.

The results of the settling tests on the RBC effluent ("B" stream) are shown in Figures 13 and 14. A large amount of biomass was present in the RBC effluent when these tests were conducted. This fibrous portion of the biomass quickly settles to a sludge depth of 1.75 inches within 10 to 15 minutes (Figure 13). This settling rate corresponds with the TSS in the overflow. The overflow TSS declines rapidly in the first few minutes reaching a steady state of ∿40 ppm within 3-5 minutes. Thus, the fibrous solids are easily removable by a clarifier or lamella filter, however, the remaining fine suspended solids will present filtration problems in the full-scale plant.

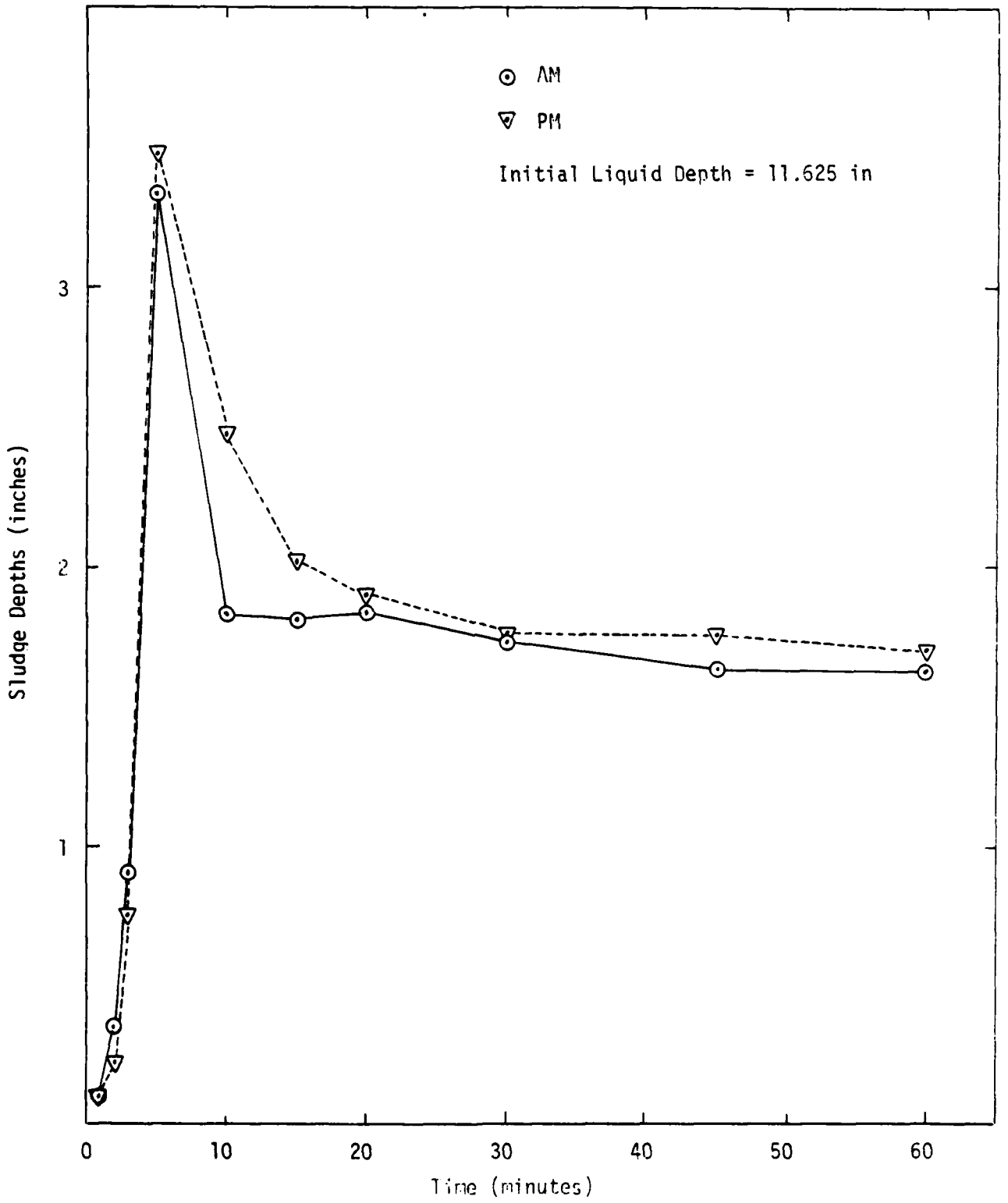


Figure 13. Sludge Depth as a Function of Settling Time

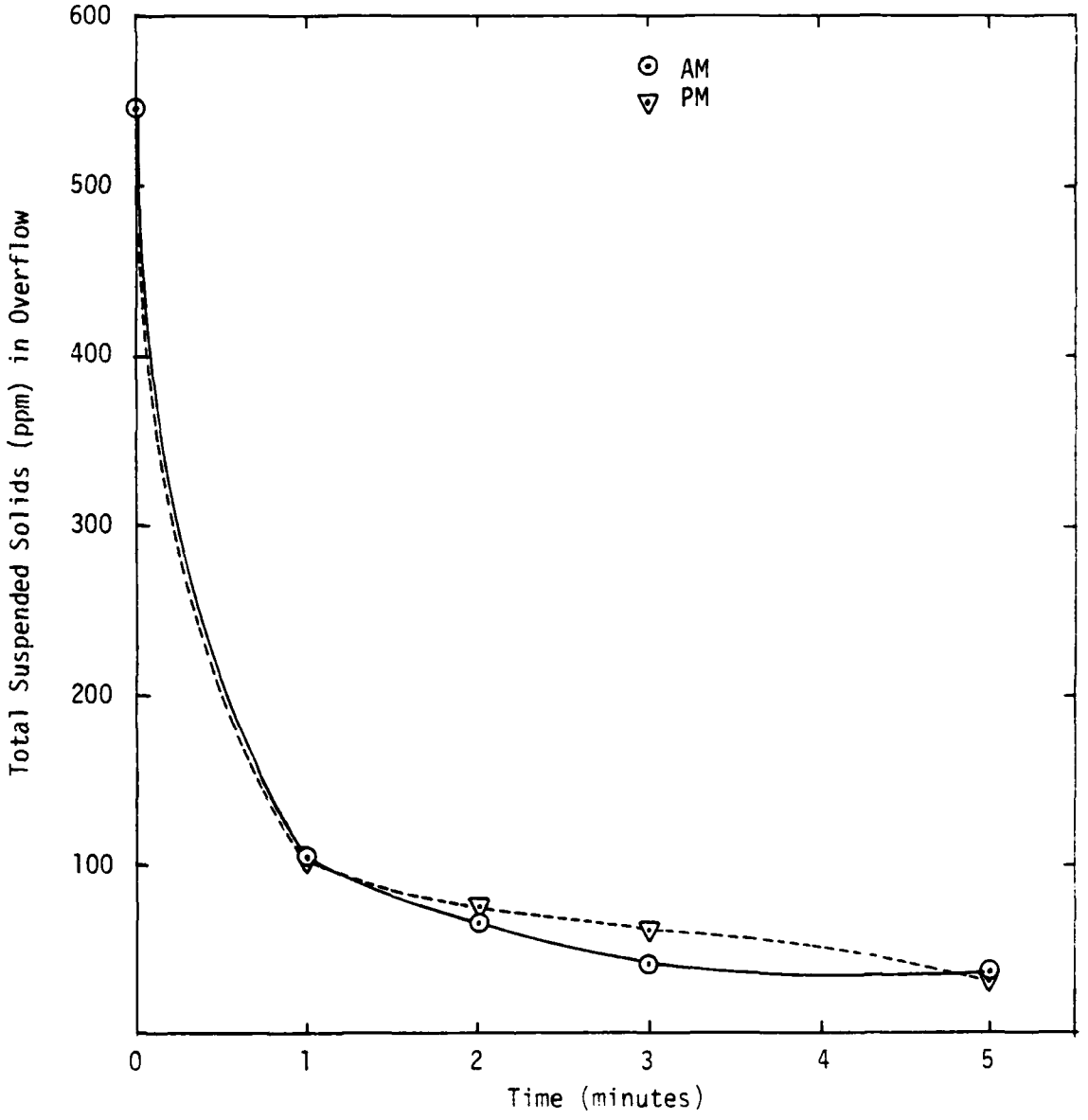


Figure 14. Total Suspended Solids Concentration in Overflow as a Function of Settling Time

H. Environmental Stress Cracking Resistance of High Density Polyethylene

The high density polyethylene, normally used for full scale RBC units, was tested in solutions of the "B" influent (no explosives) and the effluent from chamber 1 to determine if these liquids contained environmental stress cracking accelerating agents. The F_{50} (hours on test until 50% of the specimens have failed) for the influent and chamber 1 effluent compared to reference materials are presented below:

Material	F_{50}, Hours
100% Igepal (aggressive)	7-22
"B" Influent	61.9
Effluent from Chamber 1	57.5
Deionized Water (non-aggressive)	132-143
Air (non-aggressive)	166

Thus, the "B" stream and degradation products, thereof, are aggressive to the high density polyethylene normally used in full scale RBC units. These results are substantiated by visual examination of the pilot RBC unit. The polyethylene discs had deformed after seven months of operation. Metal components of the unit which were not coated with coal tar epoxy showed severe corrosion.

The results of the ESCR tests and the condition of the pilot RBC unit suggest the use of special resins with ESCR >400 hours for the full scale RBC discs. All metal parts should be coated with coal tar epoxy and inspected routinely for corrosion.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

This pilot-scale evaluation established the aerobic rotating biological contactor as a technically effective means for reducing SCOD and SBOD in the "X" Facility wastewaters. Two types of wastewaters were evaluated in a four stage pilot scale aerobic rotating biological contactor:

- the total anticipated dry weather wastewater-stream "A"
- the dry weather stream minus 546,200 gallons per day of heat exchanger condensate-stream "B"

The characteristics of the "A" stream are:

- 1306 ppm SBOD
- 1607 ppm TCOD
- 1519 ppm TBOD
- >150 ppm TSS
- 1366 ppm SCOD
- pH = 3-4
- 4 ppm ammonia-nitrogen

The "B" stream is ∿1.55 times the concentration of the "A" stream. Neither stream has sufficient concentrations of ammonia-nitrogen or phosphorus for proper biological growth. Thus, ammonia-nitrogen and phosphorus must be added in order to raise the SBOD/N/P ratio to approximately 100/5/1 for optimum biological activity. The streams must also be neutralized to a pH of 7-8 with sodium hydroxide or a combination of ammonium and sodium hydroxide.

Although the population of microorganisms in the RBC unit was unusually narrow, their tolerance of and recovery from shock loadings and other environmental stresses were sufficiently adequate to ensure viability in an industrial situation. Two potential problem areas are significant:

- The shock loading cannot go above 2.5 lb BOD/1000 ft^2/day because of D.O. limitations.
- A large decrease in BOD loadings causes significant die off of the organisms and 1 to 2 days are required to return the RBC to peak efficiency when BOD loading again returned to normal.

Operation of the aerobic pilot rotating biological contactor showed that 95-99% reduction in SBOD levels could be achieved and maintained at SBOD loadings of <2.5 lb SBOD/1000 sq. ft./day. At higher loadings, the system becomes dissolved oxygen limited. Eighty to ninety percent of the

SBOD reduction occurs in the first stage. The area of this first stage should be ∿50-60% of the total area in order to maintain dissolved oxygen levels above 1.0 ppm and handle BOD and pH shocks. Maximum effluents values which can be expected from the rotation biological contactors are:

	"A" Stream	"B" Stream
max TCOD	346-427 ppm	516-665 ppm
max TBOD	230-289 ppm	339-443 ppm

The actual effluent TBOD and TCOD will depend on the efficiency of the primary treatment, clarification, filtration and granular activated carbon in removing insoluble BOD, COD and the explosives.

When D.O. levels are maintained above 1 ppm, nitrification of ammonia in the RBC is not significant. In addition, nitrates were not found to be assimilated by the aerobic organisms in the RBC. Consequently, levels of NO_2-NO_3-N influent to the RBC are essentially the levels that will be observed in the RBC effluent. Ammonia and phosphorus levels in the RBC effluent can be maintained at relatively low levels by limiting nutrient additions to that required for BOD assimilation. With careful addition of ammonia, the ammonia levels in the effluent should be maintainable below 1 ppm.

Settling tests revealed the presence of a fibrous floc which settled rapidly and finely divided solids which did not settle. These finely divided solids consist of fungal spores, bacteria and undissolved solids. These solids present problems in filtration due to rapid growth of fungal mycelium in filtration media. If efficient filtration can be obtained, effluent TSS less than 5 ppm, the effluent quality of the "A" and "B" streams should be <60 and <105 ppm TBOD, respectively at maximum loading. At lower loadings, effluent TBOD in the 15-50 ppm range sould be obtainable.

B. Recommendations

1. Guidance for Design of Full-Scale Wastewater Treatment Facility

The following comments are offered to designers of the full-scale wastewater treatment plant so that efficient treatment of the Site "X" wastewaters can be obtained:

- the stream containing TNT from the dewatering, wet incorporation and pack operations should be pretreated. The TNT should be removed from the stream prior to its entry in the wastewater treatment plant

- equalization and primary solids removal time should be as short as possible (less than 14 hours) in order to prevent microbial growth in these tanks.

- the lines from the azeo stills should be constructed so that these wastewaters can be diverted into a separate surge tank in case of a 24-hour upset

- the pH of the equalization tanks and primary clarifiers should not not be altered (increased above 5) to discourage microbial growth

- pH adjustment to 7-8, addition of an ammonia-nitrogen source, addition of phosphates, and aeration should be accomplished immediately prior to the rotating biological contactors.

- the rotating biological contactors should be arranged in modular fashion so that one or two modules can be shut down if the plant is operating at less than full capacity

- the loading on the rotating biological contactor should be less than 2.5 lb/1000 sq. ft./day, preferably approximately 2.0 lb/1000 sq. ft./day. The rotating biological contactor shafts should be arranged in three stages with 50-60% of the media area in the initial stage

- aeration and/or a means of increasing the rotational speed of the first stage discs should be provided to increase the dissolved oxygen at peak loads or in hot weather

- clarification or filtration must take into account the ability of the fungal mycelium to rapidly clog ordinary filters

- a tertiary treatment must be provided to remove residual COD and explosives (if no pretreatment for TNT and RDX is employed).

2. Areas Requiring Additional Experimental Evaluation

The time constraints on the pilot-scale program precluded a thorough investigation of all the parameters associated with the treatability of the "X" facility wastewaters. Several questions still remain unanswered.

- If reduction in NO_2-NO_3-N is required, what is the best location of the denitrification unit. Is biological denitrification viable in a high formaldehyde environment? Should the acid concentration effluent be segregated from collective effluents before denitrification?
- If high nitrate concentrations pass through the aerobic system unchanged, will anaerobic denitrifiers grow in the aerobic effluent?
- What are the effluent constituents that are the major contributors to the observed aquatic toxicity?
- What is the feasibility of treating TNT wastes at the incorporation buildings?
- Will at-source granular activated carbon treatment of incorporation building effluents be effective? Will this affect the requirements for the tertiary granular activated carbon treatment in the wastewater treatment plant effluent?
- Can the problems observed in clarification and filtration of the wastewater during secondary treatment be overcome by the addition of flocculating agents?
- What are the accomplishments of and requirements for aerobic digestion of the biological sludges? Can thickening and flocculation increase sludge total solids?

These questions should be resolved before final design of the wastewater treatment facility is undertaken. Some of these questions can be answered by operation of bench-scale units. However, a complete pilot-scale study is preferrable to obtain performance data sufficiently reliable for design purposes.

REFERENCES

American Public Health Association (1976), *Standard Methods for the Examination of Water and Wastewater*, 14th edition, American Public Health Association, Washington, D.C.

Ames, B.N.; McCann, J. and Yamasaki (1975), "Methods for Detecting Carcinogens and Mutagens with the Salmonella/Mammalian Microsome Mutagenicity Test," *Mutation Research*, 31, 347-364.

ARRADCOM (1979), personal communication with Olin Colitti.

ASTM Test Method D1693 (1979), "Environmental Stress-Cracking of Ethylene Plastics, test for," 36, 207-215, 1970, Reapproved 1975.

Autotrol Corporation (1979), personal communication.

Peltier, W. (1978), "Methods for Measuring the Acute Toxicity of Effluents to Aquatic Organisms," EPA, Report No. EPA-600/4-78-012. NTIS, PB 276 690.

U.S. Army Engineering Division (1977), "Project Development Brochure, Part I: Functional Requirements, RDX/HMX Manufacturing Facility Waste Treatment Facilities," PDB-1.

Pilot RBC Data Sheet # A-1 (No explosives)

Date 6/25/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.2	7.65	8.4	8.4	8.65	-
Alkalinity, mg/l	112	176	268	288	290	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	750	125	50	40	25	-
Formaldehyde, mg/l	270	22.5	16.5	17	16.5	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1133	577	453	659	453	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	60.02
% BOD Reduction	-
% TOC Reduction	-

Comments: Fresh feed started flowing to RBC at 4 P.M. on 6/24/79
No explosives

Appendix A
Daily Operational Parameters for the "A" Wastewater

Pilot RBC Data Sheet # A-2 (No explosives)

Date 6/26/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.0	7.3	8.25	8.3	8.5	-
Alkalinity, mg/l	104	140	276	278	272	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	950	125	60	40	33	-
Formaldehyde, mg/l	376	22	20	21	18	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1225	364	445	240	202	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	83.90
% BOD Reduction	-
% TOC Reduction	-

Comments: No explosives

Pilot RBC Data Sheet # A-3 (No explosives)

Date 6/27/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.85	7.4	8.2	8.4	8.5	-
Alkalinity, mg/l	120	216	310	300	320	-
Dissolved Oxygen, mg/l	9.1	3.5	9.9	11.2	11.6	-
Nitrate/Nitrite, mg/l	8	4	3	2	2	-
Ammonia, mg/l	750	125	60	55	45	-
Formaldehyde, mg/l	485	18.5	15.5	17	18.5	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1188	792	396	396	277	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		76.68		
		% BOD Reduction		-		
		% TOC Reduction		-		

Comments: Additional PO_4^{-3} and NH_4NO_3 were added to the influent on 6/26/79.
No explosives

Pilot RBC Data Sheet # A-4 (No explosives)

Date 6/28/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.55	7.3	7.9	8.15	8.25	-
Alkalinity, mg/l	106	220	268	286	236	-
Dissolved Oxygen, mg/l	9.9	2.7	8.0	9.2	10.2	-
Nitrate/Nitrite, mg/l	-	-	-	-	8	-
Ammonia, mg/l	800	140	60	40	33	-
Formaldehyde, mg/l	510	97	29	18	22.5	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1199	650	325	346	353	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	70.56
% BOD Reduction	-
% TOC Reduction	-

Comments: No explosives

Pilot RBC Data Sheet # A-5 (No explosives)

Date 6/29/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.75	7.95	8.3	8.35	8.5	-
Alkalinity, mg/l	97	322	384	378	354	-
Dissolved Oxygen, mg/l	6.5	7.9	9.4	9.5	10.4	-
Nitrate/Nitrite, mg/l	-	-	-	-	5	-
Ammonia, mg/l	440	80	75	60	45	-
Formaldehyde, mg/l	275	16	19	17.5	13.5	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	196	214	114	46	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1122	184	224	231	218	-
BOD, mg/l	1567	517	717	542	567	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	80.57
% BOD Reduction	63.82
% TOC Reduction	-

Comments: BOD samples were not filtered.
No explosives

Pilot RBC Data Sheet # A-6 (No explosives)

Date 7/3/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	5.85	6.45	6.75	7.75	8.0	-
Alkalinity, mg/l	58	66	86	196	195	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	8	-
Ammonia, mg/l	720	140	75	65	55	-
Formaldehyde, mg/l	368	106	29.5	22.5	22.5	-
Total Solids, mg/l	696	-	-	-	670	-
Total Suspended Solids, mg/l	-	214	512	520	20	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1096	441	115	308	205	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 81.30

% BOD Reduction -

% TOC Reduction -

Comments: Pump failed on 6/30/79. RBC not fed over the weekend. No samples were taken on 7/2/79.
Significant growth in influent. New feed tank on 7/2/79.
No explosives

Pilot RBC Data Sheet # A-7 (No explosives)

Date 7/5/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.2	6.75	7.5	8.3	8.4	-
Alkalinity, mg/l	118	100	222	298	286	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	1.5	-
Ammonia, mg/l	600	140	105	140	95	-
Formaldehyde, mg/l	330	100	54.6	47.5	47.1	-
Total Solids, mg/l	312	-	-	-	440	-
Total Suspended Solids, mg/l	-	904	1213	705	68	-
Total Volatile Solids, mg/l	179	-	-	-	323	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1276	657	619	388	287	-
BOD, mg/l	1458	2920	170	1145	45	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 77.51

% BOD Reduction 96.91

% TOC Reduction -

Comments: No samples were taken on 7/4/79 due to holiday. BOD sample not filtered.
No explosives

Pilot RBC Data Sheet # A-8 (No explosives)

Date 7/6/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.9	6.65	7.35	8.3	8.45	-
Alkalinity, mg/l	104	80	190	274	298	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	1.5	-
Ammonia, mg/l	525	310	120	90	140	-
Formaldehyde, mg/l	-	-	47	44.6	42.3	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1281	785	372	317	275	-
BOD, mg/l	913	813	563	438	363	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		78.53		
		% BOD Reduction		60.24		
		% TOC Reduction		-		

Comments: No explosives

Pilot RBC Data Sheet # A-9 (No explosives)

Date 7/9/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.45	6.65	8.15	8.3	8.4	-
Alkalinity, mg/l	78	80	332	340	332	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	550	135	150	128	115	-
Formaldehyde, mg/l	224	53	38.5	40	41	-
Total Solids, mg/l	254	-	-	-	464	-
Total Suspended Solids, mg/l	-	457	811	587	156	-
Total Volatile Solids, mg/l	35	-	-	-	227	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1564	670	596	658	472	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 69.82
% BOD Reduction -
% TOC Reduction -

Comments: New feed on 7/6/79.
No explosives

Pilot RBC Data Sheet # A-10 (No explosives)

Date 7/10/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.35	7.05	8.15	8.3	8.3	-
Alkalinity, mg/l	72	134	334	330	326	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	550	120	170	90	125	-
Formaldehyde, mg/l	162	43.5	51.5	44.5	49.7	-
Total Solids, mg/l	396	-	-	-	666	-
Total Suspended Solids, mg/l	-	442	446	611	261	-
Total Volatile Solids, mg/l	129	-	-	-	343	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1056	448	319	305	332	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	68.56
% BOD Reduction	-
% TOC Reduction	-

Comments: No explosives

Pilot RBC Data Sheet # A-11 (No explosives)

Date 7/11/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.25	7.2	8.2	8.35	8.4	-
Alkalinity, mg/l	132	184	404	404	400	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	1.5	-
Ammonia, mg/l	525	150	260	220	270	-
Formaldehyde, mg/l	288	63.3	56	43	51.8	-
Total Solids, mg/l	401	-	-	-	521	-
Total Suspended Solids, mg/l	-	546	721	456	294	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1121	635	654	436	386	-
BOD, mg/l	759	559	459	483	408	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		65.6		
		% BOD Reduction		46.3		
		% TOC Reduction		-		

Comments: No explosives

Pilot RBC Data Sheet #A-12 (No explosives)

Date 7/12/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.7	6.95	8.05	8.3	8.35	-
Alkalinity, mg/l	90	122	361	388	392	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	725	275	120	105	100	-
Formaldehyde, mg/l	335	76.5	56	55.5	56.5	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	620	233	194	174	287	-
BOD, mg/l	456	494	306	244	219	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	53.7
% BOD Reduction	51.97
% TOC Reduction	-

Comments: Large amount of growth in influent tanks. Phosphate sludge drip added to chamber 3.
No explosives

Pilot RBC Data Sheet # A-13 (No explosives)

Date 7/13/79

Influent Flow Rate 450 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.15	5.4	5.65	6.6	6.7	-
Alkalinity, mg/l	104	32	32	66	56	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	1150	750	250	190	230	-
Formaldehyde, mg/l	396	130	73.4	53.5	79.8	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1267	693	510	630	624	-
BOD, mg/l	719	619	619	519	494	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	50.8
% BOD Reduction	31.29
% TOC Reduction	-

Comments: Continued phosphate sludge drip to chamber 3.
Flow rate increased; chamber 1 acidic.
No explosives

Pilot RBC Data Sheet # A-14 (No explosives)

Date 7/16/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	5.9	6.7	7.45	7.7	8.05	-
Alkalinity, mg/l	78	74	142	160	188	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	800	300	240	100	90	-
Formaldehyde, mg/l	552	73.7	24.9	17.7	21	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1292	833	368	248	264	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 79.6
% BOD Reduction -
% TOC Reduction -

Comments: No explosives

Pilot RBC Data Sheet # A-15 (No Explosives)

Date 7/17/79

Influent Flow Rate 450 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.35	6.5	7.15	7.4	7.55	-
Alkalinity, mg/l	90	68	104	118	139	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	1100	400	210	130	120	-
Formaldehyde, mg/l	435	106	34.9	31.8	28.2	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1126	680	474	453	297	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	73.6
% BOD Reduction	-
% TOC Reduction	-

Comments: No explosives

Pilot RBC Data Sheet # A-16 (No Explosives)

Date 7/18/79

Influent Flow Rate 450 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.25	6.4	7.25	7.5	8.0	-
Alkalinity, mg/l	68	70	126	184	256	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	7.5	-
Ammonia, mg/l	1300	400	200	120	110	-
Formaldehyde, mg/l	332	89	45	24.5	27	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	0	0	0	0	0	-
RDX, mg/l	0	0	0	0	0	-
HMX, mg/l	0	0	0	0	0	-
COD, mg/l	1197	714	459	408	450	-
BOD, mg/l	1031	614	414	197	131	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	62.4
% BOD Reduction	87.3
% TOC Reduction	-

Comments: Ammonium nitrate, phosphate and sludge drip into chamber 3 on 7/17/79. Total BOD - not filtered.

Pilot RBC Data Sheet # A-17

Date 7/19/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.7	7.8	8.15	8.2	8.25	-
Alkalinity, mg/l	115	209	264	288	292	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	14	-
Ammonia, mg/l	1300	250	100	120	110	-
Formaldehyde, mg/l	294	17	19.5	32.5	24.5	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	4.35	3.20	3.20	3.15	3.10	-
HMX, mg/l	0.75	0.60	0.60	0.60	0.60	-
COD, mg/l	1009	151	110	144	216	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	78.6
% BOD Reduction	-
% TOC Reduction	-

Comments: New feed on 7/18/79 with explosives added.
Pump overflowed - influent flow slowed.

Pilot RBC Data Sheet # A-18

Date 7/20/79

Influent Flow Rate 450 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.85	6.5	6.95	7.7	8.05	-
Alkalinity, mg/l	95	61	86	224	254	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	12	-
Ammonia, mg/l	950	175	80	75	85	-
Formaldehyde, mg/l	680	89	22.5	28	25	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	4.25	4.10	3.60	3.80	3.80	-
HMX, mg/l	0.55	0.50	0.50	0.50	0.45	-
COD, mg/l	1386	956	557	294	244	-
BOD, mg/l	1164	747	281	81	114	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	82.4
% BOD Reduction	90.2
% TOC Reduction	-

Comments: Ammonium nitrate, phosphate, sludge drip added to C-3 at 4:30 P.M. on 7/19/79.
Total BOD - not filtered.

Pilot RBC Data Sheet # A-19

Date 7/23/79

Influent Flow Rate 500 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	5.7	6.25	7.1	8.05	8.2	-
Alkalinity, mg/l	42	122	110	284	332	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	975	320	150	195	460	-
Formaldehyde, mg/l	374.5	63.7	25	29.9	26.1	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	906	680	280	64	384	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	57.6
% BOD Reduction	-
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet # A-20

Date 7/24/79

Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.85	7.05	8.1	8.35	8.45	-
Alkalinity, mg/l	180	155	402	425	426	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	700	50	40	60	52.5	-
Formaldehyde, mg/l	407.5	52.7	36.5	31.1	30.7	-
Total Solids, mg/l	672	-	-	-	744	-
Total Suspended Solids, mg/l	-	255	406	261	215	-
Total Volatile Solids, mg/l	238	-	-	-	302	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	6.45	6.45	6.00	-
HMX, mg/l	0.85	1.00	1.15	1.00	1.10	-
COD, mg/l	1034	561	331	277	261	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 75
% BOD Reduction -
% TOC Reduction -

Comments:

Pilot RBC Data Sheet # A-21

Date 7/25/79

Influent Flow Rate 500 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.7	6.15	7.25	8.0	8.15	-
Alkalinity, mg/l	124	46	148	240	260	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1350	350	150	105	120	-
Formaldehyde, mg/l	515	91	24.5	22.5	22	-
Total Solids, mg/l	285	-	-	-	486	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	1.60	0.1	0.1	0.1	0.1	-
RDX, mg/l	4.50	3.70	3.70	-	3.50	-
HMX, mg/l	0.60	0.50	0.60	0.60	0.55	-
COD, mg/l	1600	780	340	224	208	-
BOD, mg/l	1305	839	339	239	139	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		87.9		
		% BOD Reduction		89.4		
		% TOC Reduction		-		

Comments: Total BOD - not filtered.

Pilot RBC Data Sheet # A-22

Date 7/26/79

Influent Flow Rate 550 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.4	4.75	6.15	7.15	7.8	-
Alkalinity, mg/l	98	10	44	116	170	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1200	400	175	120	90	-
Formaldehyde, mg/l	213	56.9	45	29	28.4	-
Total Solids, mg/l	318	-	-	-	370	-
Total Suspended Solids, mg/l	-	172	109	65	33	-
Total Volatile Solids, mg/l	151	-	-	-	229	-
TNT, mg/l	1.35	-	1.35	BDL	BDL	-
RDX, mg/l	4.10	3.70	4.15	4.10	4.10	-
HMX, mg/l	0.60	0.40	0.40	0.60	0.65	-
COD, mg/l	1306	857	469	294	441	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	66.3
% BOD Reduction	-
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet # A-23

Date 7/27/79

Influent Flow Rate 510 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.75	5.9	6.45	7.75	8.05	-
Alkalinity, mg/l	96	38	56	232	252	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1250	400	150	97.5	85	-
Formaldehyde, mg/l	445	138	55	37.2	31.5	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	2.70	0.20	BDL	BDL	BDL	-
RDX, mg/l	6.25	6.00	5.25	5.25	3.15	-
HMX, mg/l	0.60	0.70	0.80	0.85	0.85	-
COD, mg/l	960	681	292	311	47	-
BOD, mg/l	1167	700	333	167	67	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	95.1
% BOD Reduction	94.3
% TOC Reduction	-

Comments: Soluble BOD - Sample Filtered

Pilot RBC Data Sheet # A-24

Date 7/30/79

Influent Flow Rate 480 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.7	6.05	6.55	7.6	7.95	-
Alkalinity, mg/l	92	45	66	192	205	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	520	125	84	80	72.5	-
Formaldehyde, mg/l	310	101	35	80	23	-
Total Solids, mg/l	563	-	-	-	619	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1293	740	360	320	304	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		76.49		
		% BOD Reduction		-		
		% TOC Reduction		-		

Comments:

Pilot RBC Data Sheet # A-25

Date 7/31/79

Influent Flow Rate 430 gpd
2.5 rpm

Analy	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temper ure, °C	-	-	-	-	-	-
pH	7.0	6.5	7.25	8.0	8.2	-
Alkalinity, mg/l	105	64	132	240	244	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	600	100	80	70	60	-
Formaldehyde, mg/l	355	99	41	29.5	20.5	-
Total Solids, mg/l	354	-	-	-	421	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1073	578	255	250	324	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	69.80
% BOD Reduction	-
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet # A-26

Date 8/1/79

Influent Flow Rate 411 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.9	6.6	7.4	8.1	8.2	-
Alkalinity, mg/l	98	88	172	260	278	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	950	210	150	120	70	-
Formaldehyde, mg/l	376	82	33	35	26	-
Total Solids, mg/l	322	-	-	-	329	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1098	291	378	335	315	-
BOD, mg/l	873	298	98	81.48	31.48	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 71.31

% BOD Reduction 96.39

% TOC Reduction -

Comments: BOD (soluble only) - samples filtered

Pilot RBC Data Sheet # A-27

Date 8/2/79

Influent Flow Rate 411 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.1	6.5	7.4	8.1	8.2	-
Alkalinity, mg/l	114	70	176	278	294	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	950	240	120	120	105	-
Formaldehyde, mg/l	265	71	43	39	38	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1059	659	449	326	171	-
BOD, mg/l	1115	531	248	181	198	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	83.85
% BOD Reduction	82.24
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet # A-28

Date 8/3/79

Influent Flow Rate 411 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.0	6.6	7.65	8.2	8.25	7.15
Alkalinity, mg/l	104	82	240	336	332	330
Dissolved Oxygen, mg/l	6.7	0.7	2.7	9.1	11.8	3.6
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	800	180	160	200	160	-
Formaldehyde, mg/l	320	66	36.5	37	36.5	-
Total Solids, mg/l	386	-	-	-	2451	322
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	1.0	BDL	BDL	BDL	BDL	-
RDX, mg/l	10.5	7.6	9.8	9.0	9.2	-
HMX, mg/l	1.7	0.55	1.5	0.6	0.6	-
COD, mg/l	B.N.*	512	197	142	142	142
BOD, mg/l	798	298	81	48	0	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		-		
		% BOD Reduction		100		
		% TOC Reduction		-		

Comments: *Bad number.
DO probe uncalibrated.

Pilot RBC Data Sheet #A-29

Date 8/6/79

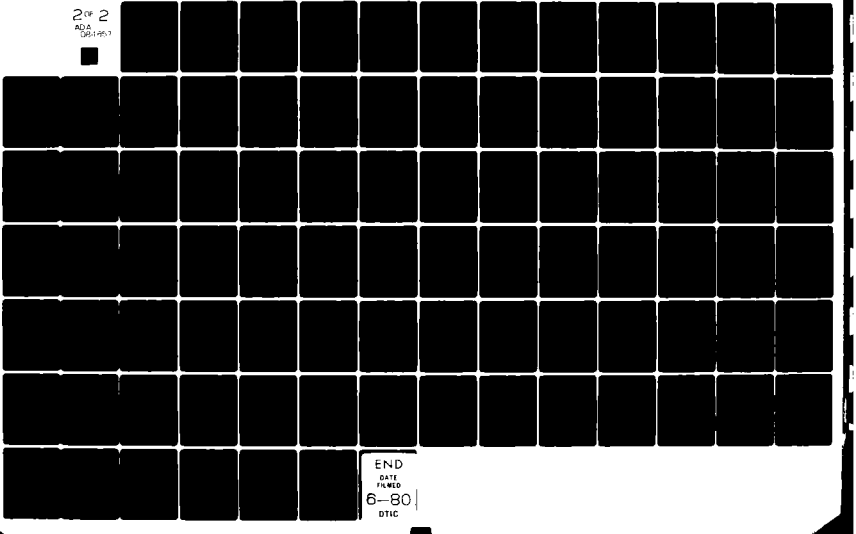
Influent Flow Rate 400 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.25	8.15	8.65	8.7	8.7	7.65
Alkalinity, mg/l	254	328	576	574	586	472
Dissolved Oxygen, mg/l	11.4	9.6	9.8	11.8	12.9	-
Nitrate/Nitrite, mg/l	-	-	-	-	4	-
Ammonia, mg/l	250	135	105	75	68	-
Formaldehyde, mg/l	37.5	34.6	39.5	31.5	41.6	-
Total Solids, mg/l	761	-	-	-	718	417
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	1.0	BDL	BDL	BDL	BDL	-
RDX, mg/l	10	10	10	10	10	-
HMX, mg/l	1.8	1.8	1.8	1.6	1.85	-
COD, mg/l	519	272	214	140	140	156
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		73.0		
		% BOD Reduction		-		
		% TOC Reduction		-		

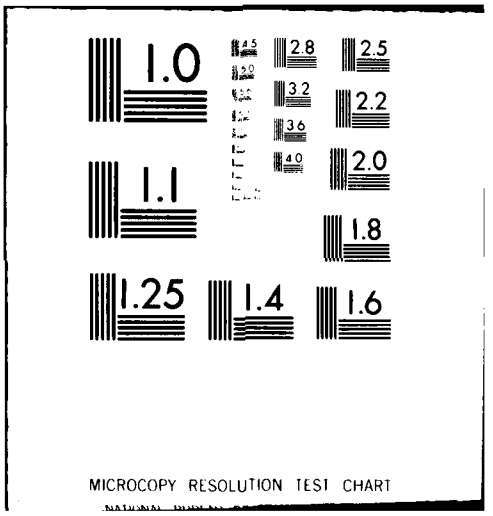
Comments: Feed problems over weekend
DO probe uncalibrated.

AD-A084 657 ATLANTIC RESEARCH CORP ALEXANDRIA VA F/G 13/2
PILOT-SCALE EVALUATION OF THE TREATABILITY OF RDX/HMX SITE 'X' --ETC(U)
APR 80 J F KITCHENS, R G HYDE, D A PRICE DAEA18-69-A-0223
UNCLASSIFIED ARC-49-5766-1 ARCSL-CR-80028 NL

2 OF 2
AD A
084657



END
DATE FILMED
6-80
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART

Pilot RBC Data Sheet # A-30

Date 8/7/79

Influent Flow Rate 450 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.35	5.9	6.55	7.7	8.15	-
Alkalinity, mg/l	100	38	52	202	243	-
Dissolved Oxygen, mg/l	11.1	0.75	0.9	5.8	12.15	-
Nitrate/Nitrite, mg/l	-	-	-	-	4	-
Ammonia, mg/l	800	160	80	60	72	-
Formaldehyde, mg/l	275	35.0	47.6	23.1	22.3	-
Total Solids, mg/l	256	-	-	-	427	-
Total Suspended Solids, mg/l	-	83	50	61.2	36	-
Total Volatile Solids, mg/l	58	-	-	-	210	-
TNT, mg/l	1.4	BDL	BDL	BDL	BDL	-
RDX, mg/l	5.2	4.1	4.1	4.8	4.6	-
HMX, mg/l	0.6	0.4	0.6	0.8	0.75	-
COD, mg/l	1297	642	350	125	109	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	91.6
% BOD Reduction	-
% TOC Reduction	-

Comments: New feed on 8/6/79
DO probe uncalibrated.

Pilot RBC Data Sheet # A-31

Date 8/8/79

Influent Flow Rate 420 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.8	6.3	7.35	7.95	8.1	7.75
Alkalinity, mg/l	90	46	134	230	214	378
Dissolved Oxygen, mg/l	0.95	0.5	0.8	4.3	11.0	-
Nitrate/Nitrite, mg/l	-	-	-	-	8	-
Ammonia, mg/l	700	-	-	-	-	50
Formaldehyde, mg/l	377.5	60.5	24.5	12	15.5	-
Total Solids, mg/l	353	-	-	-	316	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	0.4	BDL	BDL	BDL	BDL	-
RDX, mg/l	4.05	3.8	3.6	3.4	3.1	-
HMX, mg/l	0.8	0.6	0.6	0.6	0.6	-
COD, mg/l	1069	573	365	175	92	-
BOD, mg/l	1133	383	67	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 91.4
% BOD Reduction 100
% TOC Reduction -

Comments: BOD is soluble only (sample filtered)
DO very low.
DO probe uncalibrated.

Pilot RBC Data Sheet # A-32

Date 8/9/79

Influent Flow Rate 450 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.85	7.3	7.8	8.25	8.3	7.75
Alkalinity, mg/l	204	168	304	442	336	446
Dissolved Oxygen, mg/l	8.4	1.0	1.3	8.3	11.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	20	-
Ammonia, mg/l	1100	160	50	52	42.5	-
Formaldehyde, mg/l	257.5	134	30.5	27.5	22.6	-
Total Solids, mg/l	624	-	-	-	779	-
Total Suspended Solids, mg/l	-	188	267	113	142	-
Total Volatile Solids, mg/l	197	-	-	-	289	-
TNT, mg/l	0.7	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	6.1	6.8	5.6	5.6	4.0	BDL
HMX, mg/l	1.1	1.05	1.0	1.0	0.2	BDL
COD, mg/l	1111	474	152	106	90	121
BOD, mg/l	1174	507.4	140.8	91	0	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	94.9
% BOD Reduction	100
% TOC Reduction	-

Comments: BOD soluble only (sample filtered)
DO very low
DO probe uncalibrated.

Pilot RBC Data Sheet # A-33

Date 8/10/79

Influent Flow Rate 420 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.75	7.5	7.85	8.1	7.8	7.85
Alkalinity, mg/l	216	246	378	382	228	-
Dissolved Oxygen, mg/l	12.4	0.6	1.5	7.85	9.45	2.8
Nitrate/Nitrite, mg/l	-	-	-	-	70	-
Ammonia, mg/l	200	200	95	70	65	-
Formaldehyde, mg/l	187.5	43	12.7	10.3	19.8	-
Total Solids, mg/l	6833	-	-	-	724	469
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	0.9	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	7.5	7.6	6.9	6.3	-	BDL
HMX, mg/l	1.6	1.2	1.2	0.6	-	BDL
COD, mg/l	1093	420	220	176	208	208
BOD, mg/l	1090S(1280T)	381	131	30.6	155.6S(180.6T)	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	81.0
% BOD Reduction	85.6
% TOC Reduction	-

Comments: Total and soluble BOD in influent and effluent compared.
D.O. in RBC too low - highly anaerobic - nitrate concentration very high
DO probe uncalibrated

Pilot RBC Data Sheet # A-34

Date 8/13/79

Influent Flow Rate 420 gpd
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.7	7.5	8.3	7.8	7.9	-
Alkalinity, mg/l	246	244	424	248	250	-
Dissolved Oxygen, mg/l	14.8	1.5	10.8	13.6	15	-
Nitrate/Nitrite, mg/l	-	-	-	-	60	-
Ammonia, mg/l	200	175	120	90	100	-
Formaldehyde, mg/l	197.5	82.5	82.5	82.5	67.5	-
Total Solids, mg/l	428	-	-	-	685	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	3.5	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	8.9	5.6	3.9	2.4	-	BDL
HMX, mg/l	1.3	1.3	-	-	-	BDL
COD, mg/l	1213	530	510	696	-	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 42.6
% BOD Reduction -
% TOC Reduction -

Comments: DO probe uncalibrated

Pilot RBC Data Sheet # A-35

Date 8/14/79

Influent Flow Rate No flow overnight
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.95	8.3	8.35	6.55	6.7	-
Alkalinity, mg/l	402	496	353	135	143	-
Dissolved Oxygen, mg/l	3.7	10.3	12.8	14.0	14.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	-	-
Ammonia, mg/l	240	140	115	95	90	-
Formaldehyde, mg/l	287.5	135	130	81	90	-
Total Solids, mg/l	266	-	-	-	545	-
Total Suspended Solids, mg/l	-	500	509	68	78	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	-	-	-	-	-	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction -

% BOD Reduction -

% TOC Reduction -

Comments: DO probe uncalibrated

Pilot RBC Data Sheet # A-36

Date 8/15/79

Influent Flow Rate pump failure
2.5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.6	8.35	8.35	8.2	8.35	7.6
Alkalinity, mg/l	252	316	318	260	254	218
Dissolved Oxygen, mg/l	8.05	3.8	11.2	11.8	13.4	-
Nitrate/Nitrite, mg/l	-	-	-	-	35	-
Ammonia, mg/l	260	-	-	-	90	-
Formaldehyde, mg/l	95	92.5	105	69	69	-
Total Solids, mg/l	365	-	-	-	446	373
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	-	-	6.4	5.7	6.4	BDL
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	543	37	74	267	207	-
BOD, mg/l	469	82	144	282	119	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction - 61.9

% BOD Reduction - 74.6

% TOC Reduction - -

Comments: Pump failure overnight.
DO probe uncalibrated.

Pilot RBC Data Sheet # A-37

Date 8/16/79

Influent Flow Rate 480 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.25	5.9	5.95	6.25	6.8	8.2
Alkalinity, mg/l	214	84	92	100	118	-
Dissolved Oxygen, mg/l	15.8	2.4	1.6	2.0	11.0	-
Nitrate/Nitrite, mg/l	-	-	-	-	10	-
Ammonia, mg/l	840	300	200	128	84	-
Formaldehyde, mg/l	403	195	95	33	28	-
Total Solids, mg/l	288	-	-	-	380	182
Total Suspended Solids, mg/l	-	60	70	42	62	-
Total Volatile Solids, mg/l	67	-	-	-	177	57
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	4.2	3.5	3.0	3.0	3.0	BDL
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1226	977	651	582	107	-
BOD, mg/l	1301	839	626	351	251	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	91.3
% BOD Reduction	80.7
% TOC Reduction	-

Comments: Increased rotation of RBC to 5 rpm - 4 PM 8/15/79.
New feed tank 4 PM 8/15/79; add pH controller on influent line.
DO uncalibrated.

Pilot RBC Data Sheet # A-38

Date 8/17/79

Influent Flow Rate 480 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.3	6.3	7.0	7.55	7.9	-
Alkalinity, mg/l	171	103	100	110	128	-
Dissolved Oxygen, mg/l	15.6	6.0	6.4	9.6	11.9	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	320	180	90	70	70	-
Formaldehyde, mg/l	422.5	205	70	30	6	-
Total Solids, mg/l	367	-	-	-	583	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	5.4	5.2	3.4	4.1	3.7	0
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1200	940	560	560	400	-
BOD, mg/l	1425	900	650	550	375	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 66.7

% BOD Reduction 73.7

% TOC Reduction -

Comments: DO probe uncalibrated.

Pilot RBC Data Sheet # A-39

Date 8/20/79

Influent Flow Rate Pump Failure
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	20	21	-	-	-	-
pH	8.65	8.7	8.5	8.7	8.6	-
Alkalinity, mg/l	202	286	182	303	244	-
Dissolved Oxygen, mg/l	13.6	11.3	11.2	12.9	13.4	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	550	100	70	70	60	-
Formaldehyde, mg/l	480	11	13	13	15	-
Total Solids, mg/l	645	-	-	-	720	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	-	-	-
RDX, mg/l	6.5	5.5	4.5	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1503	480	363	384	259	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	82.8
% BOD Reduction	-
% TOC Reduction	-

Comments: New feed tank 4 PM 8/19/79
DO probe uncalibrated

Pilot RBC Data Sheet # A-40

Date 8/21/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	22	23	-	-	-	-
pH	8.0	7.6	7.6	7.85	8.0	-
Alkalinity, mg/l	126	221	180	184	187	-
Dissolved Oxygen, mg/l	14.0	0.4	0.4	0.9	0.9	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	280	90	35	65	45	-
Formaldehyde, mg/l	460	64	54	36.5	34.5	-
Total Solids, mg/l	520	-	-	-	704	-
Total Suspended Solids, mg/l	-	172	281	384	248	-
Total Volatile Solids, mg/l	181	-	-	-	372	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	6.5	5.5	5.5	5.5	5.5	BDL
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1622	684	646	487	441	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	72.8
% BOD Reduction	-
% TOC Reduction	-

Comments: Started 1, 2 recycle; dissolved oxygen very low.
DO probe uncalibrated.

Pilot RBC Data Sheet # A-41

Date 8/22/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	19	19	-	-	-	-
pH	8.0	7.6	7.7	8.45	8.6	-
Alkalinity, mg/l	238	190	187	232	254	-
Dissolved Oxygen, mg/l	14.2	0.8	1.7	11.2	11.1	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	275	50	40	40	40	-
Formaldehyde, mg/l	470	29	33	25	33	-
Total Solids, mg/l	520	-	-	-	681	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	BDL	BDL	BDL	BDL
RDX, mg/l	-	-	6.3	5.5	5.1	BDL
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1411	309	299	319	303	-
BOD, mg/l	1406	143	93	106	6	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	78.5
% BOD Reduction	99.6
% TOC Reduction	-

Comments: Dissolved oxygen still low
DO probe uncalibrated

Pilot RBC Data Sheet # A-42

Date 8/23/79

Influent Flow Rate Pump failure overnight
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	20	21	-	-	-	-
pH	7.8	8.3	8.7	8.55	8.55	-
Alkalinity, mg/l	132	298	301	292	274	-
Dissolved Oxygen, mg/l	5.0	10.1	11.9	11.8	13.2	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	400	50	50	42.5	40	-
Formaldehyde, mg/l	227.5	33.5	35.5	30.5	35	-
Total Solids, mg/l	585	-	-	-	702	-
Total Suspended Solids, mg/l	-	684	334	334	191	-
Total Volatile Solids, mg/l	230	-	-	-	344	-
TNT, mg/l	-	BDL	BDL	BDL	-	-
RDX, mg/l	-	4.1	4.1	4.1	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1347	554	426	444	317	-
BOD, mg/l	1189	139	114	126	51	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		76.5		
		% BOD Reduction		95.7		
		% TOC Reduction		-		

Comments: DO probe uncalibrated.

Pilot RBC Data Sheet # A-43

Date 8/24/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.7	7.4	7.35	7.5	8.6	-
Alkalinity, mg/l	240	144	144	152	238	-
Dissolved Oxygen, mg/l	12.9	0.7	1.0	1.5	10.3	-
Nitrate/Nitrite, mg/l	-	-	-	-	-	-
Ammonia, mg/l	700	75	60	55	52.5	-
Formaldehyde, mg/l	605	485	26	18	26	-
Total Solids, mg/l	442	-	-	-	589	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	3.0	2.5	1.6	2.0	2.2	BDL
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1528	336	287	324	237	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	84.5
% BOD Reduction	-
% TOC Reduction	-

Comments: New feed - 3 PM on 8/23/79
Begin 1, 2, 3 recycle - 3 PM on 8/23/79
DOprobe uncalibrated.

Pilot RBC Data Sheet # A-44

Date 8/28/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.2	7.4	7.4	7.7	8.2	7.7
Alkalinity, mg/l	-	-	-	-	-	-
Dissolved Oxygen, mg/l	4.3	1.8	3.1	6.1	11.0	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	250	75	50	50	-	47.5
Formaldehyde, mg/l	465	25.5	25.5	21.5	28.5	-
Total Solids, mg/l	556	-	-	-	518	-
Total Suspended Solids, mg/l	-	110	70	69	119	-
Total Volatile Solids, mg/l	262	-	-	-	241	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	5.2	3.2	3.2	4.0	4.8	BDL
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1277	326	421	332	215	261
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	83.2
% BOD Reduction	-
% TOC Reduction	-

Comments: Pump stopped on 8/26/79; no analyses on 8/27/79.
New feed 10 AM on 8/24/79
DO probe uncalibrated.

Pilot RBC Data Sheet # A-45

Date 8/29/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	26	25	-	-	-	-
pH	8.1	7.55	7.65	7.85	8.05	7.75
Alkalinity, mg/l	117	267	262	290	286	326
Dissolved Oxygen, mg/l	3.6	1.8	4.1	7.8	12.3	-
Nitrate/Nitrite, mg/l	-	-	-	-	4	-
Ammonia, mg/l	600	100	60	50	35	-
Formaldehyde, mg/l	500	34.5	24.5	22.5	24.5	-
Total Solids, mg/l	658	-	-	-	671	494
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	7.4	5.8	6.0	5.8	6.6	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1224	332	352	281	266	281
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		78.3		
		% BOD Reduction		-		
		% TOC Reduction		-		

Comments: DO probe uncalibrated.

Pilot RBC Data Sheet # A-46

Date 8/30/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	25	24.5	-	-	-	-
pH	8.0	8.0	8.1	8.15	8.0	7.8
Alkalinity, mg/l	104	314	310	324	190	357
Dissolved Oxygen, mg/l	6.5	5.5	7.2	8.9	11.8	-
Nitrate/Nitrite, mg/l	-	-	-	-	35	-
Ammonia, mg/l	200	-	-	-	32.5	-
Formaldehyde, mg/l	415	23	23	16.5	25.5	-
Total Solids, mg/l	671	-	-	-	716	879
Total Suspended Solids, mg/l	-	209	190	186	124	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	6.6	3.2	3.4	3.4	3.4	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1080	731	652	474	253	553
BOD, mg/l	532	86	25.5	25	35	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		76.6		
		% BOD Reduction		93.4		
		% TOC Reduction		-		

Comments: DO probe uncalibrated.

Pilot RBC Data Sheet # A-47

Date 8/31/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.2	7.85	8.0	8.05	8.1	-
Alkalinity, mg/l	137	298	312	302	290	-
Dissolved Oxygen, mg/l	2.5	4.5	7.8	10.0	12.8	-
Nitrate/Nitrite, mg/l	-	-	-	-	8	-
Ammonia, mg/l	200	-	-	-	40	-
Formaldehyde, mg/l	30	23.5	19.5	19	21.5	-
Total Solids, mg/l	630	-	-	-	558	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	5.8	5.4	5.4	5.4	6.6	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	650	244	152	276	163	-
BOD, mg/l	400	20	83	86	56	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	74.9
% BOD Reduction	86.0
% TOC Reduction	-

Comments: New tank 10 AM on 8/30/79; leak in feed tank; pumped influent into old tank which contained lots of microorganisms.
DO probe uncalibrated.

Pilot RBC Data Sheet # A-48

Date 9/4/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	26.5	25.5	-	-	-	-
pH	7.95	7.65	7.65	7.65	7.7	-
Alkalinity, mg/l	198	187	198	180	160	-
Dissolved Oxygen, mg/l	1.9	4.0	4.4	5.0	7.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	45	-
Ammonia, mg/l	80	-	-	-	3.2	-
Formaldehyde, mg/l	70	18	21.5	15.5	15	-
Total Solids, mg/l	904	-	-	-	823	-
Total Suspended Solids, mg/l	-	166	122	143	126	-
Total Volatile Solids, mg/l	530	-	-	-	406	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	409	129	79	103	71	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	82.6
% BOD Reduction	-
% TOC Reduction	-

Comments: Labor Day 9/3/79 - RBC very cloudy.

Pilot RBC Data Sheet # A-49

Date 9/5/79

Influent Flow Rate 576 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.1	4.8	4.8	4.75	4.75	-
Alkalinity, mg/l	116	8	10	4	4	-
Dissolved Oxygen, mg/l	5.5	4.3	5.0	6.0	6.4	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	650	400	230	110	150	-
Formaldehyde, mg/l	590	184	143	110	118	-
Total Solids, mg/l	757	-	-	-	841	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	3.3	3.4	1.9	3.3	4.2	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1326	867	916	858	795	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		40.0		
		% BOD Reduction		-		
		% TOC Reduction		-		

Comments: Flow increased to 576 gpd on 9/4/79.
Feed 1,2; new feed on 9/4/79 - no explosives
Ammonia decreased to 1/3000 gal

Pilot RBC Data Sheet #A-51

Date 9/7/79

Influent Flow Rate 480 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	26.5	26	-	-	-	-
pH	8.25	7.0	7.0	7.9	8.4	-
Alkalinity, mg/l	126	160	162	214	242	-
Dissolved Oxygen, mg/l	2.1	0.8	0.8	5.3	7.25	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	800	175	60	50	42.5	-
Formaldehyde, mg/l	610	50	47	12	10	-
Total Solids, mg/l	435	-	-	-	530	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	158	-	-	-	302	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	4.0	2.8	2.8	3.2	2.2	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1100	295	265	236	165	-
BOD, mg/l	670	111	76	69	48	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	85.0
% BOD Reduction	92.8
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet # A-52

Date 9/8/79

Influent Flow Rate 480 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	-	-	-	-	-	-
Alkalinity, mg/l	-	-	-	-	-	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	-	-
Ammonia, mg/l	520	80	60	47.5	40	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	4.1	3.6	3.2	2.6	2.6	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	981	179	119	151	151	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	85.0
% BOD Reduction	-
% TOC Reduction	-

Comments: Weekend sample

Pilot RBC Data Sheet # A-53

Date 9/9/79

Influent Flow Rate 480 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	-	-	-	-	-	-
Alkalinity, mg/l	-	-	-	-	-	-
Dissolved Oxygen, mg/l	-	-	-	-	-	-
Nitrate/Nitrite, mg/l	-	-	-	-	-	-
Ammonia, mg/l	630	60	30	24	26	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	-	-	BDL	BDL	-
RDX, mg/l	4.0	-	-	2.8	2.6	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1165	366	224	211	163	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction 86.0
% BOD Reduction -
% TOC Reduction -

Comments: Weekend sample

Pilot RBC Data Sheet # A-54

Date 9/10/79

Influent Flow Rate 480 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	24	22	-	-	-	-
pH	8.1	6.5	6.5	7.8	8.4	-
Alkalinity, mg/l	84	76	76	216	268	-
Dissolved Oxygen, mg/l	8.45	1.0	0.8	6.4	7.5	-
Nitrate/Nitrite, mg/l	2	-	-	-	2	-
Ammonia, mg/l	600	60	45	30	30	-
Formaldehyde, mg/l	595	37.5	22	16	20	-
Total Solids, mg/l	556	-	-	-	488	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	4.2	4.2	2.6	3.2	3.2	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1286	378	358	262	159	-
BOD, mg/l	717	39	24	10	18	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	87.6
% BOD Reduction	97.5
% TOC Reduction	-

Comments: New Tank 600 ml NH_4OH

Pilot RBC Data Sheet # A-55

Date 9/11/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	24	24	-	-	-	-
pH	8.3	6.8	6.75	8.05	8.25	-
Alkalinity, mg/l	119	105	98	219	246	-
Dissolved Oxygen, mg/l	6.7	1.2	1.6	6.65	7.75	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	700	40	35	30	20	-
Formaldehyde, mg/l	580	27.5	31	28	22	-
Total Solids, mg/l	646	-	-	-	515	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	BDL	BDL	BDL	BDL	-
RDX, mg/l	-	5.0	4.3	4.8	4.2	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1245	384	342	224	216	-
BOD, mg/l	569	66	62	11	35	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		82.7		
		% BOD Reduction		93.9		
		% TOC Reduction		-		

Comments:

Pilot RBC Data Sheet # A-56

Date 9/12/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	22	22.5	-	-	-	-
pH	8.2	7.2	7.2	8.1	8.1	-
Alkalinity, mg/l	102	252	242	312	312	-
Dissolved Oxygen, mg/l	1.95	1.2	1.1	6.2	7.3	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	400	25	22.4	27	26	-
Formaldehyde, mg/l	460	25	20	21	21	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	7.2	7.0	6.1	6.1	5.8	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1014	284	284	219	219	-
BOD, mg/l	558	53	28	0	0	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		78.4		
		% BOD Reduction		100		
		% TOC Reduction		-		

Comments:

Pilot RBC Data Sheet # A-57

Date 9/13/79

Influent Flow Rate 450 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	22	21	-	-	-	-
pH	8.2	5.3	5.25	6.0	6.75	-
Alkalinity, mg/l	78	18	16	31	54	-
Dissolved Oxygen, mg/l	7.95	0.85	0.9	0.9	5.2	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	660	140	77	40	20	-
Formaldehyde, mg/l	635	113	107	26	16	-
Total Solids, mg/l	645	-	-	-	906	-
Total Suspended Solids, mg/l	-	267	349	297	254	-
Total Volatile Solids, mg/l	244	-	-	-	533	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1495	486	526	262	246	-
BOD, mg/l	932	203	210	65	28	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	83.6
% BOD Reduction	97
% TOC Reduction	-

Comments: New feed 11 AM on 9/12/79. Used 300 ml NH_4OH

Pilot RBC Data Sheet #A-58

Date 9/14/79

Influent Flow Rate 480 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.2	7.0	6.85	8.2	8.2	-
Alkalinity, mg/l	82	130	118	324	368	-
Dissolved Oxygen, mg/l	5.6	0.6	0.8	5.3	6.35	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	1040	15	9	6.5	5.4	-
Formaldehyde, mg/l	675	20	16	16	16.5	-
Total Solids, mg/l	788	-	-	-	882	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	5.5	7.5	-	5.5	6.6	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1449	435	435	332	253	-
BOD, mg/l	813	45	15	0	0	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		82.5		
		% BOD Reduction		100		
		% TOC Reduction		-		

Comments: Dissolved oxygen very low.

Pilot RBC Data Sheet # B-1

Date 9/17/79

Influent Flow Rate 200 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	18	17.5	-	-	-	-
pH	8.75	5.2	5.2	4.95	5.4	-
Alkalinity, mg/l	73	12	12	7	13	-
Dissolved Oxygen, mg/l	8.6	1.6	1.4	3.95	5.5	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	630	250	140	110	50	-
Formaldehyde, mg/l	790	173	130	113	81	-
Total Solids, mg/l	660	-	-	-	667	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	BN*	598	558	430	351	-
BOD, mg/l	660	243	220	180	127	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		72.5		
		% BOD Reduction		80.8		
		% TOC Reduction		-		

Comments: *Bad number

Pilot RBC Data Sheet # B-2

Date 9/18/79

Influent Flow Rate 200 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	25	25	-	-	-	-
pH	8.5	5.25	5.2	6.0	7.7	-
Alkalinity, mg/l	140	32	30	44	158	-
Dissolved Oxygen, mg/l	7.55	1.1	1.1	1.0	5.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	-	-
Ammonia, mg/l	1000	320	270	72	30	-
Formaldehyde, mg/l	900	175	157.5	41	15	-
Total Solids, mg/l	1300	-	-	-	910	-
Total Suspended Solids, mg/l	-	237	238	181	129	-
Total Volatile Solids, mg/l	573	-	-	-	486	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	6.5	5.7	3.3	5.2	6.5	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2602	885	825	410	233	-
BOD, mg/l	1318	364	329	78	15	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	91.0
% BOD Reduction	98.9
% TOC Reduction	-

Comments: Start "B" solution on 9/17/79.
Large excess acetic acid

Pilot RBC Data Sheet # B-3

Date 9/19/79

Influent Flow Rate 200 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.45	6.1	6.1	7.8	8.8	-
Alkalinity, mg/l	130	60	66	260	466	-
Dissolved Oxygen, mg/l	7.1	0.3	0.3	1.7	5.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	1.5	-
Ammonia, mg/l	840	168	100	25	16	-
Formaldehyde, mg/l	1070	1025	97.5	32	33	-
Total Solids, mg/l	1162	-	-	-	1104	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	2.5	2.0	2.0	2.2	2.5	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2513	794	784	486	381	-
BOD, mg/l	1565	302	268	94	58	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	84.8
% BOD Reduction	96.3.
% TOC Reduction	-

Comments: Large excess acetic acid

Pilot RBC Data Sheet # B-4

Date 9/20/79

Influent Flow Rate 240 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	23	14	-	-	-	-
pH	8.2	5.1	5.1	6.1	7.3	-
Alkalinity, mg/l	110	22	22	54	180	-
Dissolved Oxygen, mg/l	7.1	0.8	0.7	0.8	2.9	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	1680	360	330	80	25	-
Formaldehyde, mg/l	1260	276	250	75	33	-
Total Solids, mg/l	1148	-	-	-	1530	-
Total Suspended Solids, mg/l	-	324	343	455	455	-
Total Volatile Solids, mg/l	744	-	-	-	823	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	2.7	2.2	2.2	2.2	2.2	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2300	1173	1288	815	600	-
BOD, mg/l	1330	629	558	274	174	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	73.9
% BOD Reduction	86.9
% TOC Reduction	-

Comments: Speed up flow to 240 gpd.
Large excess of acetic acid

Pilot RBC Data Sheet # S-5

Date 9/21/79

Influent Flow Rate 240 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.6	5.0	4.9	5.2	6.7	-
Alkalinity, mg/l	126	24	16	32	90	-
Dissolved Oxygen, mg/l	6.65	2.3	2.1	1.6	3.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	1680	440	330	100	30	-
Formaldehyde, mg/l	990	500	375	155	50	-
Total Solids, mg/l	1292	-	-	-	1410	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	2.9	2.5	2.3	2.3	2.3	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2434	1369	1369	1095	778	-
BOD, mg/l	1548	678	653	477	318	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	68.0
% BOD Reduction	79.5
% TOC Reduction	-

Comments: Large excess of acetic acid

Pilot RBC Data Sheet #B-6

Date 9/24/79

Influent Flow Rate 220 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	16	14	-	-	-	-
pH	6.5	7.8	8.6	8.7	8.65	-
Alkalinity, mg/l	94	324	488	558	574	-
Dissolved Oxygen, mg/l	3.6	6.3	9.75	9.8	9.8	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	1080	30	21	9	13	-
Formaldehyde, mg/l	1290	75	35	33	31	-
Total Solids, mg/l	1097	-	-	-	1203	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	2.5	2.5	2.2	2.3	2.3	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2209	422	291	233	313	-
BOD, mg/l	1440	157	40	6	18	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		85.8		
		% BOD Reduction		98.8		
		% TOC Reduction		-		

Comments: Slowed flow to 220 gpd 9:00 AM on 9/21/79.
Problems with pH controller on influent.
Large excess of acetic acid

Pilot RBC Data Sheet # B-7

Date 9/25/79

Influent Flow Rate 220 gpd
2 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	18.5	16	-	-	-	-
pH	6.6	5.7	5.75	6.15	6.7	-
Alkalinity, mg/l	80	38	38	44	56	-
Dissolved Oxygen, mg/l	4.9	0.7	0.6	2.5	6.75	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	1680	330	240	55	35	-
Formaldehyde, mg/l	1030	205	210	100	55	-
Total Solids, mg/l	1130	-	-	-	1216	-
Total Suspended Solids, mg/l	-	62	66	62	92	-
Total Volatile Solids, mg/l	838	-	-	-	848	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2424	996	975	780	678	-
BOD, mg/l	1113	306	338	190	203	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		72.1		
		% BOD Reduction		81.8		
		% TOC Reduction		-		

Comments: Problems with pH controller on influent.

Pilot RBC Data Sheet #B-8

Date 9/26/79

Influent Flow Rate 220 gpd
2 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	22	21	-	-	-	-
pH	11.15	7.3	7.0	7.6	8.1	-
Alkalinity, mg/l	275	171	178	186	210	-
Dissolved Oxygen, mg/l	4.1	0.9	0.6	1.35	6.8	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	1560	210	165	70	20	-
Formaldehyde, mg/l	1030	205	210	100	55	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	1.4	2.1	2.1	2.1	2.0	-
HMX, mg/l	0.1	BDL	BDL	BDL	BDL	-
COD, mg/l	2126	807	802	646	520	-
BOD, mg/l	1343	426	409	283	235	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		75.5		
		% BOD Reduction		82.5		
		% TOC Reduction		-		

Comments: Problems with pH controller on influent.
Large excess of acetic acid

Pilot RBC Data Sheet #B-9

Date 9/27/79

Influent Flow Rate 220 gpd
2 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	5.1	6.9	6.9	7.6	8.15	-
Alkalinity, mg/l	30	170	176	212	268	-
Dissolved Oxygen, mg/l	2.4	1.3	0.6	4.65	8.2	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	1320	90	37.5	35	22	-
Formaldehyde, mg/l	890	100	130	46	35.5	-
Total Solids, mg/l	1121	-	-	-	1048	-
Total Suspended Solids, mg/l	-	52	54	56	58	-
Total Volatile Solids, mg/l	474	-	-	-	351	-
TNT, mg/l	0.1	BDL	BDL	BDL	BDL	-
RDX, mg/l	2.3	1.8	1.6	1.6	1.6	-
HMX, mg/l	BDL	BDL	BDL	BDL	BDL	-
COD, mg/l	2152	787	748	583	520	-
BOD, mg/l	743	374	345	267	178	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		75.8		
		% BOD Reduction		76.0		
		% TOC Reduction		-		

Comments: Problems with pH controller on influent.
Large excess of acetic acid

Pilot RBC Data Sheet #B-10

Date 9/28/79

Influent Flow Rate 220 gpd
2 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	22	22	-	-	-	-
pH	4.8	6.8	6.9	7.6	8.1	8.5
Alkalinity, mg/l	12	162	160	230	334	634
Dissolved Oxygen, mg/l	2.1	0.4	0.4	5.55	7.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	4	-
Ammonia, mg/l	1680	100	95	50	24	-
Formaldehyde, mg/l	1020	130	125	45	31	-
Total Solids, mg/l	1095	-	-	-	1257	1091
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	2.3	1.6	1.6	1.6	1.0	BDL
HMX, mg/l	0.1	0.1	0.1	0.1	0.1	BDL
COD, mg/l	1879	676	750	541	371	216
BOD, mg/l	1057	319	320	142	65	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		80.26		
		% BOD Reduction		93.9		
		% TOC Reduction		-		

Comments: Problems with pH controller on influent.
New tank

Pilot RBC Data Sheet # B-11

Date 10/1/79

Influent Flow Rate 220 gpd
2 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	22	22	-	-	-	-
pH	10.1	7.8	7.5	8.6	8.5	8.2
Alkalinity, mg/l	132	366	364	650	592	588
Dissolved Oxygen, mg/l	3.7	0.8	0.7	5.5	7.4	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1200	60	50	18	18	-
Formaldehyde, mg/l	550	90	70	37	31	-
Total Solids, mg/l	1152	-	-	-	964	825
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	2.3	2.3	1.8	1.6	1.6	BDL
HMX, mg/l	0.1	0.1	0	0	0	BDL
COD, mg/l	1370	446	446	310	233	186
BOD, mg/l	607	69	95	21	0	-
TOC, mg/l	110	110	85	-	80	-
		% COD Reduction		82.99		
		% BOD Reduction		100		
		% TOC Reduction		27.27		

Comments: Problems with pH controller on influent.

Pilot RBC Data Sheet # B-12

Date 10/2/79

Influent Flow Rate 220 gpd
2 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	22	24	-	-	-	-
pH	4.8	6.8	6.8	7.8	8.5	8.4
Alkalinity, mg/l	2	132	136	294	436	652
Dissolved Oxygen, mg/l	3.2	0.8	0.6	0.9	4.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	480	70	63	16	12.5	-
Formaldehyde, mg/l	770	80	60	21	25	-
Total Solids, mg/l	925	-	-	-	930	970
Total Suspended Solids, mg/l	-	68	72	63	48	-
Total Volatile Solids, mg/l	374	-	-	-	249	289
TNT, mg/l	0.1	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	2.3	1.7	1.7	1.8	1.7	BDL
HMX, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
COD, mg/l	1282	481	462	292	262	200
BOD, mg/l	616	188	173	91	49	-
TOC, mg/l	530	70	30	30	30	-
		% COD Reduction		79.56		
		% BOD Reduction		92.1		
		% TOC Reduction		94.34		

Comments: Problems with pH controller on influent.

Pilot RBC Data Sheet # B-13

Date 10/3/79

Influent Flow Rate 220 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	19	19	-	-	-	-
pH	9.25	7.2	7.1	7.6	7.9	8.5
Alkalinity, mg/l	88	146	144	272	406	814
Dissolved Oxygen, mg/l	6.8	5.7	5.8	6.1	6.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	560	80	80	22.5	24	-
Formaldehyde, mg/l	460	105	125	34	29	-
Total Solids, mg/l	1090	-	-	-	1239	1207
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	-	-
RDX, mg/l	2.0	1.7	0.4	1.7	-	-
HMX, mg/l	BDL	BDL	BDL	BDL	-	-
COD, mg/l	1234	728	689	551	378	315
BOD, mg/l	690	323	318	141	76	0
TOC, mg/l	150	185	120	-	-	-
		% COD Reduction		69.37		
		% BOD Reduction		89.0		
		% TOC Reduction		-		

Comments: Problems with pH controller on influent.

Pilot RBC Data Sheet # B-14

Date 10/4/79

Influent Flow Rate 220 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	18.5	18	-	-	-	-
pH	8.35	6.0	6.1	6.8	7.3	8.75
Alkalinity, mg/l	108	46	48	90	142	588
Dissolved Oxygen, mg/l	8.8	2.1	1.6	3.8	4.9	13
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	1320	320	120	24	25	-
Formaldehyde, mg/l	1340	320	345	53	33	-
Total Solids, mg/l	1146	-	-	-	1072	975
Total Suspended Solids, mg/l	-	212	254	224	227	-
Total Volatile Solids, mg/l	395	-	-	-	394	362
TNT, mg/l	1.6	1.8	BDL	BDL	BDL	BDL
RDX, mg/l	*	*	*	*	*	30
HMX, mg/l	0.6	0.7	0.6	0.6	0.6	BDL
COD, mg/l	1868	934	973	654	529	514
BOD, mg/l	1274	591	620	342	305	-
TOC, mg/l	810	355	50	255	255	-
		% COD Reduction		71.68		
		% BOD Reduction		76.1		
		% TOC Reduction		68.52		

Comments: New feed - 4 PM on 10/3/79.
*off scale

Pilot RBC Data Sheet # B-15

Date 10/5/79

Influent Flow Rate 220 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	5.5	7.6	7.7	8.4	8.55	8.5
Alkalinity, mg/l	44	410	412	546	558	692
Dissolved Oxygen, mg/l	8.4	1.6	1.1	4.5	7.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	600	9	6	3	3	-
Formaldehyde, mg/l	960	45	40	16	17	-
Total Solids, mg/l	476	-	-	-	526	614
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	2.2	1.1	BDL	BDL	BDL	BDL
RDX, mg/l	*	*	*	*	*	BDL
HMX, mg/l	0.9	0.6	0.4	0.6	0.6	BDL
COD, mg/l	1856	392	353	204	204	267
BOD, mg/l	1320	139	181	86	96	-
TOC, mg/l	810	120	100	85	145	-
		% COD Reduction		89.0		
		% BOD Reduction		92.7		
		% TOC Reduction		82.10		

Comments: Problems with pH controller.
*off scale

Pilot RBC Data Sheet # B-16

Date 10/8/79

Influent Flow Rate 220 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	10	10	-	-	-	-
pH	7.7	7.45	7.5	8.3	8.5	-
Alkalinity, mg/l	40	222	226	416	548	-
Dissolved Oxygen, mg/l	7.6	6.5	7.9	8.9	9.1	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	540	24	8	11	10	-
Formaldehyde, mg/l	270	22.5	20	19	23	-
Total Solids, mg/l	1077	-	-	-	1014	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	3.1	4.7	4.2	-	-	-
HMX, mg/l	BDL	BDL	BDL	0.1	0.2	-
COD, mg/l	1012	370	389	311	222	-
BOD, mg/l	583	142	142	103	110	-
TOC, mg/l	870	115	100	55	50	-
		% COD Reduction		78.1		
		% BOD Reduction		81.1		
		% TOC Reduction		94.25		

Comments: Tank overflow, no feed; pH controller fixed.

Pilot RBC Data Sheet # B-17

Date 10/9/79

Influent Flow Rate 220 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	16	16	-	-	-	-
pH	7.7	7.1	7.15	8.5	8.55	-
Alkalinity, mg/l	146	170	176	430	466	-
Dissolved Oxygen, mg/l	9.3	2.0	2.4	8.2	9.0	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	720	20	12	12	4.8	-
Formaldehyde, mg/l	990	53	57	48	47	-
Total Solids, mg/l	1105	-	-	-	1008	-
Total Suspended Solids, mg/l	-	52	82	58	51	-
Total Volatile Solids, mg/l	400	-	-	-	295	-
TNT, mg/l	0.7	BDL	BDL	BDL	BDL	1.8
RDX, mg/l	4.1	3.1	2.5	3.0	4.2	7.6
HMX, mg/l	0.1	BDL	BDL	BDL	0.1	0.3
COD, mg/l	2405	409	342	548	471	-
BOD, mg/l	1810	155	151	58	81	-
TOC, mg/l	900	150	128	113	47	-
		% COD Reduction		80.4		
		% BOD Reduction		95.5		
		% TOC Reduction		94.78		

Comments: low tank.

Pilot RBC Data Sheet # B-18

Date 10/10/79

Influent Flow Rate 220 gpd
5 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	8	8	-	-	-	-
pH	7.4	6.4	6.5	8.2	8.5	-
Alkalinity, mg/l	130	68	72	294	376	-
Dissolved Oxygen, mg/l	9.8	6.8	7.2	10.2	11.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1320	150	27	-	-	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	996	-	-	-	917	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	0.1	BDL	BDL	BDL	-	-
RDX, mg/l	4.8	4.8	4.6	4.3	-	-
HMX, mg/l	0.2	0.1	0.2	0.2	-	-
COD, mg/l	-	-	-	-	-	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	885	193	135	122	110	-
		% COD Reduction		-		
		% BOD Reduction		-		
		% TOC Reduction		87.57		

Comments: Electricity went off - could not finish analyses

Pilot RBC Data Sheet #B-19

Date 10/11/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	9	9	-	-	-	-
pH	7.3	6.5	6.65	8.0	8.25	-
Alkalinity, mg/l	106	78	80	200	250	-
Dissolved Oxygen, mg/l	10.0	6.4	5.5	10.0	10.4	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	600	30	24	30	30	-
Formaldehyde, mg/l	1520	78	65	60	68	-
Total Solids, mg/l	959	-	-	-	968	-
Total Suspended Solids, mg/l	-	64	75	74	108	-
Total Volatile Solids, mg/l	350	-	-	-	382	-
TNT, mg/l	1.6	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	6.0	5.3	4.3	5.1	3.4	1.2
HMX, mg/l	0.3	0.1	0.1	0.1	BDL	BDL
COD, mg/l	2228	506	449	419	404	BDL
BOD, mg/l	1406	37	20	0	0	-
TOC, mg/l	820	150	133	117	118	-
		% COD Reduction		81.9		
		% BOD Reduction		100		
		% TOC Reduction		85.61		

Comments: Electricity off for approx. 6 hours on 10/10/79.
Flow and rotation stopped.

Pilot RBC Data Sheet # B-20

Date 10/12/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	11.5	11.9	-	-	-	-
pH	7.3	7.1	7.3	8.5	8.5	-
Alkalinity, mg/l	124	174	184	406	422	-
Dissolved Oxygen, mg/l	9.7	4.6	4.45	9.3	10.0	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	720	40	20	26	18	-
Formaldehyde, mg/l	1650	67	53	41	40	-
Total Solids, mg/l	984	-	-	-	853	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	2.6	1.8	BDL	0.2	0.6	BDL
RDX, mg/l	6.9	6.8	6.0	2.2	6.5	BDL
HMX, mg/l	0.3	0.3	BDL	BDL	0.3	BDL
COD, mg/l	2165	535	387	133	266	-
BOD, mg/l	1960	321	280	148	143	-
TOC, mg/l	810	125	115	128	133	-
		% COD Reduction		87.7		
		% BOD Reduction		92.7		
		% TOC Reduction		83.58		

Comments:

Pilot RBC Data Sheet # B-21

Date 10/15/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	8	8	-	-	-	-
pH	7.3	7.2	7.1	8.2	8.2	8.1
Alkalinity, mg/l	124	206	212	436	446	814
Dissolved Oxygen, mg/l	10.6	5.3	6.5	10.4	11.5	3.45
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1440	55	40	33	28	-
Formaldehyde, mg/l	725	33	21	21	21	-
Total Solids, mg/l	925	-	-	-	883	1266.8
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	0.4	0.4	BDL
RDX, mg/l	4.6	BDL	4.5	6.2	6.2	1.4
HMX, mg/l	0.5	BDL	0.3	0.3	0.3	BDL
COD, mg/l	1818	549	436	394	318	555
BOD, mg/l	1416	37	12	13	0	-
TOC, mg/l	790	145	117	128	115	-
		% COD Reduction		82.5		
		% BOD Reduction		100		
		% TOC Reduction		85.44		

Comments:

Pilot RBC Data Sheet # B-22

Date 10/16/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	13	12	-	-	-	-
pH	7.85	6.4	6.4	7.8	8.1	8.0
Alkalinity, mg/l	108	82	78	318	430	530
Dissolved Oxygen, mg/l	10.0	4.3	3.8	8.25	9.5	1.5
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	600	40	28	30	36	-
Formaldehyde, mg/l	501	34.5	29.5	28.5	22.5	-
Total Solids, mg/l	742	-	-	-	1896	
Total Suspended Solids, mg/l	-	344	348	547	204	-
Total Volatile Solids, mg/l	303	-	-	-	1184	374
TNT, mg/l	BDL	BDL	0.1	BDL	-	-
RDX, mg/l	4.6	4.6	6.0	2.2	-	-
HMX, mg/l	0.2	0.2	0.2	0.2	-	-
COD, mg/l	2129	509	302	392	332	201
BOD, mg/l	2465	544	519	153	30	-
TOC, mg/l	755	100	95	115	115	-
		% COD Reduction		84.41		
		% BOD Reduction		98.8		
		% TOC Reduction		84.77		

Comments: New feed - 3 PM 10/15/79

Pilot RBC Data Sheet # B-23

Date 10/17/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	13	12	-	-	-	-
pH	7.8	6.4	7.1	8.3	8.4	8.1
Alkalinity, mg/l	106	62	154	316	334	416
Dissolved Oxygen, mg/l	10	4.2	5.4	9.7	10.2	1.4
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	500	22.5	21	24	22.5	-
Formaldehyde, mg/l	1230	72	47	45	50	-
Total Solids, mg/l	754	-	-	-	1278	888
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	0.2	0.2	0.1	BDL
RDX, mg/l	2.9	2.9	4.1	4.7	3.9	3.8
HMX, mg/l	0.1	0.1	0.1	0.1	0.1	0.1
COD, mg/l	2213	420	340	288	272	184
BOD, mg/l	1717	190	120	67	67	-
TOC, mg/l	890	138	120	133	115	-
		% COD Reduction		87.71		
		% BOD Reduction		96.1		
		% TOC Reduction		87.08		

Comments:

Pilot RBC Data Sheet # B-24

Date 10/18/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	14.5	16	-	-	-	-
pH	7.7	7.1	7.1	8.0	8.1	7.8
Alkalinity, mg/l	108	178	174	306	320	402
Dissolved Oxygen, mg/l	9.6	.8	4.3	9.8	10.8	2.1
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1000	30	32	23	21	-
Formaldehyde, mg/l	132	45	41	33	35	-
Total Solids, mg/l	789	-	-	-	714	850
Total Suspended Solids, mg/l	-	0.2	205	0.8	4.2	-
Total Volatile Solids, mg/l	292	-	-	-	234	357
TNT, mg/l	1.8	1.0	BDL	BDL	BDL	BDL
RDX, mg/l	6.4	5.1	5.1	5.1	5.1	2.0
HMX, mg/l	0.3	0.2	0.2	0.2	0.2	BDL
COD, mg/l	2145	930	407	326	326	358
BOD, mg/l	1424	84	59	27	27	-
TOC, mg/l	810	127	122	110	130	-
		% COD Reduction		84.8		
		% BOD Reduction		98.1		
		% TOC Reduction		83.95		

Comments:

Pilot RBC Data Sheet # B-25

Date 10/19/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.1	7.0	7.0	7.9	8.0	7.6
Alkalinity, mg/l	74	224	234	318	322	39
Dissolved Oxygen, mg/l	10.3	5.0	4.6	9.2	11.2	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	900	40	17.5	26	31.5	-
Formaldehyde, mg/l	1120	65	47	43	36	-
Total Solids, mg/l	745	-	-	-	758	799
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	1.1	1.1	4.3	4.3	4.3	-
HMX, mg/l	BDL	BDL	BDL	BDL	BDL	-
COD, mg/l	2132	478	515	382	456	383
BOD, mg/l	1745	155	111	74	62	-
TOC, mg/l	805	155	145	135	125	-
		% COD Reduction		78.61		
		% BOD Reduction		96.4		
		% TOC Reduction		98.14		

Comments:

Pilot RBC Data Sheet # B-26

Date 10/22/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.1	7.3	7.3	7.9	8.0	7.6
Alkalinity, mg/l	82	388	392	390	390	482
Dissolved Oxygen, mg/l	8.0	3.3	4.2	9.2	10.4	2.9
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	650	47.5	55	48	34	-
Formaldehyde, mg/l	720	54	47	38	37	-
Total Solids, mg/l	860	-	-	-	860	852
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2010	375	365	352	270	332
BOD, mg/l	1801	217	234	111	96	-
TOC, mg/l	655	140	140	132	115	-
		% COD Reduction		86.57		
		% BOD Reduction		94.7		
		% TOC Reduction		82.44		

Comments:

Pilot RBC Data Sheet # B-27

Date 10/23/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	18.5	20	-	-	-	-
pH	6.9	7.15	7.1	7.4	7.9	7.7
Alkalinity, mg/l	80	344	328	360	404	502
Dissolved Oxygen, mg/l	9.3	2.3	1.8	5.0	8.8	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	600	20	28	36	39	-
Formaldehyde, mg/l	1370	43	39	35	38	-
Total Solids, mg/l	957	-	-	-	885	790
Total Suspended Solids, mg/l	-	292	180	75	47	-
Total Volatile Solids, mg/l	305	-	-	-	295	216
TNT, mg/l	0.1	BDL	BDL	BDL	BDL	-
RDX, mg/l	5.2	≥6.5	≥6.5	1.5	2.1	-
HMX, mg/l	0.2	0.2	0.2	0.1	0.1	-
COD, mg/l	2847	547	566	584	482	496
BOD, mg/l	1535	85	82	51	43	-
TOC, mg/l	1045	110	97	118	75	-
		% COD Reduction		83.1		
		% BOD Reduction		96.4		
		% TOC Reduction		92.82		

Comments:

Pilot RBC Data Sheet # B-28

Date 10/24/79

Influent Flow Rate 216 qpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	13	11	-	-	-	-
pH	7.1	7.2	7.0	7.3	8.0	7.7
Alkalinity, mg/l	70	288	258	296	354	426
Dissolved Oxygen, mg/l	9.0	2.45	2.8	6.9	9.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	550	9	10	9	8.5	-
Formaldehyde, mg/l	1050	37	36	26	29	-
Total Solids, mg/l	748	-	-	-	886	666
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	5.2	-	-	-	4.7	-
HMX, mg/l	0.2	BDL	BDL	BDL	0.2	-
COD, mg/l	2087	286	382	321	290	254
BOD, mg/l	1535	85	82	51	43	-
TOC, mg/l	180	125	105	110	110	-
		% COD Reduction		86.10		
		% BOD Reduction		97.2		
		% TOC Reduction		38.89		

Comments:

Pilot RBC Data Sheet # B-29

Date 10/25/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	10.5	9	-	-	-	-
pH	7.15	6.9	6.8	7.15	7.9	7.7
Alkalinity, mg/l	56	208	194	210	290	386
Dissolved Oxygen, mg/l	9.6	6.5	5.6	8.0	10.3	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	800	9	10	10	9	-
Formaldehyde, mg/l	1600	41	33	29	29	-
Total Solids, mg/l	698	-	-	-	827	596
Total Suspended Solids, mg/l	-	141	214	167	329	-
Total Volatile Solids, mg/l	219	-	-	-	332	154
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2068	274	310	350	292	178
BOD, mg/l	1555	126	96	59	64	-
TOC, mg/l	945	85	110	100	112	-
		% COD Reduction		85.88		
		% BOD Reduction		95.9		
		% TOC Reduction		88.15		

Comments:

Pilot RBC Data Sheet # B-30

Date 10/26/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	9	8	-	-	-	-
pH	7.5	7.4	7.1	7.5	8.0	7.75
Alkalinity, mg/l	84	312	272	322	350	394
Dissolved Oxygen, mg/l	9.5	6.2	5.7	9.0	10.8	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	800	6	8	6	4	-
Formaldehyde, mg/l	770	37	28	27	23	-
Total Solids, mg/l	856	-	-	-	788	640
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	-	-	-
RDX, mg/l	1.4	0	2.5	2.5	2.5	-
HMX, mg/l	BDL	BDL	BDL	0.2	0.2	-
COD, mg/l	2180	361	342	274	274	175
BOD, mg/l	1338	80	70	40	33	-
TOC, mg/l	883	108	90	125	105	-
		% COD Reduction		87.43		
		% BOD Reduction		97.5		
		% TOC Reduction		88.11		

Comments:

Pilot RBC Data Sheet # B-31

Date 10/29/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	10	10.5	-	-	-	-
pH	6.9	7.3	7.3	7.55	7.9	7.6
Alkalinity, mg/l	580	362	366	372	366	414
Dissolved Oxygen, mg/l	9.0	7.4	6.5	9.1	10.2	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	750	16	15	15	13	-
Formaldehyde, mg/l	1340	71	20	23	24	-
Total Solids, mg/	799	-	-	-	848	756
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	-	-
RDX, mg/l	5.6	5.3	2.0	4.1	-	-
HMX, mg/l	0.4	0.4	0.1	0.4	-	-
COD, mg/l	1939	445	445	342	291	204
BOD, mg/l	1568	29	16	19	11	-
TOC, mg/l	935	155	90	103	90	-
		% COD Reduction		84.99		
		% BOD Reduction		99.3		
		% TOC Reduction		90.37		

Comments:

Pilot RBC Data Sheet # B-32

Date 10/30/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	7.2	7.5	7.5	7.9	8.1	7.7
Alkalinity, mg/l	82	432	424	422	412	490
Dissolved Oxygen, mg/l	7.25	7.7	7.6	10.8	11.4	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	920	22.5	26	16	21	-
Formaldehyde, mg/l	920	28	32	29	26	-
Total Solids, mg/l	729	-	-	-	902	704
Total Suspended Solids, mg/l	-	758	498	472	194	-
Total Volatile Solids, mg/l	306	-	-	-	400	198
TNT, mg/l	1.2	BDL	BDL	BDL	BDL	-
RDX, mg/l	6.8	4.3	4.3	3.9	4.8	1.4
HMX, mg/l	0.4	0.2	0.2	0.1	0.3	0.1
COD, mg/l	1807	403	385	366	293	221
BOD, mg/l	1468	46	34	42	31	-
TOC, mg/l	512	130	93	83	100	-
		% COD Reduction		83.79		
		% BOD Reduction		97.9		
		% TOC Reduction		80.47		

Comments:

Pilot RBC Data Sheet # B-33

Date 10/31/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	10	9.5	-	-	-	-
pH	6.8	7.3	7.1	7.25	8.0	7.7
Alkalinity, mg/l	56	272	248	256	340	384
Dissolved Oxygen, mg/l	9.2	6.3	4.75	6.5	10.6	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	920	17.5	18	12	20	-
Formaldehyde, mg/l	81	52	35	26	29	-
Total Solids, mg/l	805	-	-	-	995	757
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
RDX, mg/l	2.1	2.3	1.2	6.5	5.8	5.8
HMX, mg/l	BDL	0.2	0.2	0.2	0.2	0.2
COD, mg/l	2164	455	312	398	364	209
BOD, mg/l	1140	91	54	41	26	-
TOC, mg/l	230	57	87	95	98	-
		% COD Reduction		83.18		
		% BOD Reduction		97.7		
		% TOC Reduction		57.39		

Comments:

Pilot RBC Data Sheet # B-34

Date 11/1/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	10.5	10	-	-	-	-
pH	7.3	7.5	7.3	7.55	8.0	8.7
Alkalinity, mg/l	70	320	312	318	326	210
Dissolved Oxygen, mg/l	8.8	6.75	5.6	7.9	10.4	8.5
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	800	12	13	11	10	-
Formaldehyde, mg/l	890	43	35	31	29	-
Total Solids, mg/l	869	-	-	-	1026	419
Total Suspended Solids, mg/l	-	42	47	51	70	-
Total Volatile Solids, mg/l	331	-	-	-	446	101
TNT, mg/l	3.6	2.8	1.7	1.7	1.7	-
RDX, mg/l	*	*	*	*	*	-
HMX, mg/l	0.9	0.8	0.8	0.8	0.8	-
COD, mg/l	2099	394	69	278	296	0
BOD, mg/l	1372	112	31	22	8	0
TOC, mg/l	835	58	58	72	72	-
		% COD Reduction		85.90		
		% BOD Reduction		99.4		
		% TOC Reduction		91.38		

Comments: * Off scale

Pilot RBC Data Sheet # B-35

Date 11/2/79

Influent Flow Rate 216 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	17	18	-	-	-	-
pH	7.0	7.25	7.4	7.6	8.0	-
Alkalinity, mg/l	58	330	328	332	334	-
Dissolved Oxygen, mg/l	5.0	2.0	4.5	7.0	8.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	640	16	18	15	18	-
Formaldehyde, mg/l	1220	39	33	27	28	-
Total Solids, mg/l	808	-	-	-	882	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	2.4	2.9	2.5	2.5	2.7	-
HMX, mg/l	BDL	BDL	BDL	BDL	BDL	-
COD, mg/l	2571	1300	1480	1327	1094	18
BOD, mg/l	1528	78	67	59	55	-
TOC, mg/l	775	435	385	400	265	-
		% COD Reduction		57.45		
		% BOD Reduction		96.4		
		% TOC Reduction		65.81		

Comments:

Pilot RBC Data Sheet # B-36

Date 11/5/79

Influent Flow Rate 250 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	6.8	3.6	3.55	3.55	3.7	-
Alkalinity, mg/l	50	-	-	-	-	-
Dissolved Oxygen, mg/l	7.4	10.7	10.3	10.6	10.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1240	350	120	120	110	-
Formaldehyde, mg/l	1420	380	392.5	327.5	200	-
Total Solids, mg/l	908	-	-	-	1234	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	0.6	0.6	0.6	BDL	BDL	-
RDX, mg/l	5.8	5.8	3.7	3.7	3.1	-
HMX, mg/l	4	4	BDL	BDL	BDL	-
COD, mg/l	2986	2783	2692	2679	2462	-
BOD, mg/l	1701	*	*	*	*	-
TOC, mg/l	990	895	940	765	750	-
		% COD Reduction		17.9		
		% BOD Reduction		-		
		% TOC Reduction		24.24		

Comments: * Too high

Pilot RBC Data Sheet #B-37

Date 11/6/79

Influent Flow Rate 250 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	8	6.5	-	-	-	-
pH	8.3	3.9	3.9	3.9	3.75	6.9
Alkalinity, mg/l	112	0	0	0	0	238
Dissolved Oxygen, mg/l	9.4	11.6	11.4	11.4	11.8	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	840	300	270	130	80	-
Formaldehyde, mg/l	1460	325	325	352.5	253.5	-
Total Solids, mg/l	843	-	-	-	1214	1316
Total Suspended Solids, mg/l	-	195	144	104	74	-
Total Volatile Solids, mg/l	272	-	-	-	571	574
TNT, mg/l	BDL	0.2	BDL	BDL	BDL	BDL
RDX, mg/l	4.0	5.0	2.6	2.6	3.8	1.2
HMX, mg/l	BDL	BDL	BDL	BDL	BDL	BDL
COD, mg/l	2917	2746	2835	2643	2232	2054
BOD, mg/l	1808	*	*	*	*	-
TOC, mg/l	1075	1028	917	810	615	-
		% COD Reduction		23.48		
		% BOD Reduction		-		
		% TOC Reduction		42.79		

Comments: * Too high

Pilot RBC Data Sheet # B-38

Date 11/7/79

Influent Flow Rate 250 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	10	9	-	-	-	-
pH	7.7	3.8	3.9	3.7	3.7	-
Alkalinity, mg/l	78	0	0	0	0	-
Dissolved Oxygen, mg/l	9.4	10.6	10.6	10.8	10.9	-
Nitrate/Nitrite, mg/l					2	-
Ammonia, mg/l	1120	47.5	30	48	52	-
Formaldehyde, mg/l	1700	60	65	57.5	62.5	-
Total Solids, mg/l	974	-	-	-	1536	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	BDL	BDL	BDL	BDL	-
RDX, mg/l	1.1	1.0	0.5	0.5	0.5	-
HMX, mg/l	BDL	BDL	BDL	BDL	BDL	-
COD, mg/l	2825	3378	2720	2601	2541	-
BOD, mg/l	1467	*	*	*	*	-
TOC, mg/l	1075	1175	1020	1015	950	-
		% COD Reduction		10.1		
		% BOD Reduction		-		
		% TOC Reduction		11.63		

Comments: * Too high

Pilot RBC Data Sheet #B-39

Date 11/8/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	8	5.5	-	-	-	-
pH	7.95	3.9	3.65	3.5	3.4	-
Alkalinity, mg/l	68	0	0	0	0	-
Dissolved Oxygen, mg/l	10.8	11.6	11.0	11.8	11.9	
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1400	21	33	20	6	-
Formaldehyde, mg/l	1450	630	550	515	332.5	
Total Solids, mg/l	861	-	-	-	929	-
Total Suspended Solids, mg/l	-	21	33	20	6	-
Total Volatile Solids, mg/l	304	-	-	-	340	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2543	2213	2213	2155	2213	-
BOD, mg/l	1433	-	-	-	-	-
TOC, mg/l	1100	947	1035	1015	1045	-
		% COD Reduction		12.98		
		% BOD Reduction		-		
		% TOC Reduction		5.00		

Comments:

Pilot RBC Data Sheet # B-40

Date 11/9/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	11	10.5	-	-	-	-
pH	8.1	4.1	3.8	3.65	3.55	5.9
Alkalinity, mg/l	82	0	0	0	0	71.5
Dissolved Oxygen, mg/l	9.9	10.05	9.5	10.05	10.3	-
Nitrate/Nitrite, mg/l	-	-	-	-	1	-
Ammonia, mg/l	1190	720	440	110	90	-
Formaldehyde, mg/l	1002	565	570	430	282.5	-
Total Solids, mg/l	816	-	-	-	1035	1372
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	BDL	1.0	0.7	0.7	BDL	-
RDX, mg/l	2.8	3.9	3.4	3.4	1.0	-
HMX, mg/l	BDL	BDL	BDL	BDL	BDL	-
COD, mg/l	44	0	88	0	59	0
BOD, mg/l	1474	-	-	-	-	-
TOC, mg/l	1080	1070	1070	1055	988	-
		% COD Reduction		-		
		% BOD Reduction		-		
		% TOC Reduction		8.52		

Comments:

Pilot RBC Data Sheet # B-41

Date 11/12/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	10	7	-	-	-	-
pH	7.5	5.1	5.6	6.1	6.8	6.35
Alkalinity, mg/l	94	26	44	56	64	166
Dissolved Oxygen, mg/l	10.9	12.0	12.2	12.6	12.8	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1260	400	140	40	32.5	-
Formaldehyde, mg/l	1360	430	200	110	60	-
Total Solids, mg/l	1038	-	-	-	1190	954
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2595	1767	1857	2058	1852	1942
BOD, mg/l	1410	739	564	543	459	-
TOC, mg/l	935	770	663	530	478	-
		% COD Reduction		28.63		
		% BOD Reduction		67.43		
		% TOC Reduction		48.88		

Comments:

Pilot RBC Data Sheet # B-42

Date 11/13/79

Influent Flow Rate 220gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	11	9.5	-	-	-	-
pH	7.8	5.9	5.5	5.05	6.0	-
Alkalinity, mg/l	68	26	22	14	38	-
Dissolved Oxygen, mg/l	9.35	9.45	9.8	10.4	10.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	740	300	140	90	62.5	-
Formaldehyde, mg/l	850	290	185	135	85	-
Total Solids, mg/l	781	-	-	-	1010	-
Total Suspended Solids, mg/l	-	9	20	19	67	-
Total Volatile Solids, mg/l	287	-	-	-	462	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2564	1823	1396	1346	1816	-
BOD, mg/l	1629	737	662	651	589	-
TOC, mg/l	1015	500	455	470	395	-
		% COD Reduction		29.17		
		% BOD Reduction		63.84		
		% TOC Reduction		61.08		

Comments:

Pilot RBC Data Sheet # B-43

Date 11/14/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	8	5.5	-	-	-	-
pH	4.0	5.25	6.15	6.4	6.8	-
Alkalinity, mg/l	0	18	32	38	48	-
Dissolved Oxygen, mg/l	9.9	10.7	11.2	11.8	11.9	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	980	240	80	45	22	-
Formaldehyde, mg/l	960	295	115	65	45	-
Total Solids, mg/l	587	-	-	-	974	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2053	1305	1255	960	1027	-
BOD, mg/l	1475	670	575	534	500	-
TOC, mg/l	1020	385	380	152	190	-
		% COD Reduction		49.96		
		% BOD Reduction		66.10		
		% TOC Reduction		81.37		

Comments:

Pilot RBC Data Sheet # B-44

Date 11/15/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	12.4	14.5	-	-	-	-
pH	7.3	6.4	6.4	6.5	6.6	7.9
Alkalinity, mg/l	64	48	50	50	50	738
Dissolved Oxygen, mg/l	10.5	7.65	8.1	9.0	9.05	3.8
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	1470	240	70	55	40	-
Formaldehyde, mg/l	940	140	130	100	95	-
Total Solids, mg/l	806	-	-	-	1048	507
Total Suspended Solids, mg/l	-	1705	92	272	183	-
Total Volatile Solids, mg/l	280	-	-	-	561	206
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1895	927	900	887	837	847
BOD, mg/l	1208	458	453	449	455	-
TOC, mg/l	835	190	228	162	250	-
		% COD Reduction		55.83		
		% BOD Reduction		62.33		
		% TOC Reduction		70.06		

Comments:

Pilot RBC Data Sheet # B-45

Date 11/16/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	13.5	12.5	-	-	-	-
pH	3.5	4.9	5.6	6.2	6.8	7.8
Alkalinity, mg/l	0		20	30	64	146
Dissolved Oxygen, mg/l	9.9	4.5	4.1	5.95	6.1	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	1450	360	90	15	15	-
Formaldehyde, mg/l	1380	267	115	85	32.5	-
Total Solids, mg/l	673	-	-	-	812	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1976	975	738	968	534	474
BOD, mg/l	1217	557	302	210	123	-
TOC, mg/l	895	200	120	120	52	-
		% COD Reduction		72.98		
		% BOD Reduction		89.89		
		% TOC Reduction		94.19		

Comments: RBC brought inside

Pilot RBC Data Sheet # B-46

Date 11/19/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	15	18	-	-	-	-
pH	8.7	7.8	7.9	8.3	8.5	7.9
Alkalinity, mg/l	92	416	438	452	494	554
Dissolved Oxygen, mg/l	9.5	0.6	4.2	8.3	8.1	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	980	6	6.5	6.5	11	-
Formaldehyde, mg/l	1450	75	65	37.5	35	-
Total Solids, mg/l	884	-	-	-	1318	1143
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1751	182	182	175	214	175
BOD, mg/l	996	19	15	5	2	-
TOC, mg/l	950	40	75	15	50	-
		% COD Reduction		87.78		
		% BOD Reduction		99.80		
		% TOC Reduction		94.74		

Comments

Pilot RBC Data Sheet # B-47

Date 11/20/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	16	18.5	-	-	-	-
pH	9.2	7.7	8.2	8.35	8.5	7.9
Alkalinity, mg/l	162	376	476	478	497	544
Dissolved Oxygen, mg/l	8.9	3.2	8.1	8.7	8.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	4	-
Ammonia, mg/l	700	4.0	22	12	27	-
Formaldehyde, mg/l	1130	50	35	27	29	-
Total Solids, mg/l	931	-	-	-	905	995
Total Suspended Solids, mg/l	-	44	33	6	30	-
Total Volatile Solids, mg/l	383	-	-	-	354	370
TNT, mg/l	0	0	0	0	0	0
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1829	104	156	171	195	140
BOD, mg/l	1349	25	25	25	19	-
TOC, mg/l	905	65	55	50	22	-
		% COD Reduction		92.30		
		% BOD Reduction		98.59		
		% TOC Reduction		97.57		

Comments:

Pilot RBC Data Sheet # B-48

Date 11/21/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	16	19	-	-	-	-
pH	6.2	7.0	8.2	8.5	8.6	8.0
Alkalinity, mg/l	48	116	520	542	546	552
Dissolved Oxygen, mg/l	8.8	3.8	6.0	8.3	8.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	1260	30	11	9	12	-
Formaldehyde, mg/l	850	87.5	40	27	26	-
Total Solids, mg/l	731	-	-	-	966	1024
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	0	0	0	0	0	0
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1811	604	177	189	205	283
BOD, mg/l	1406	289	31	21	15	-
TOC, mg/l	775	125	70	110	95	-
		% COD Reduction		88.68		
		% BOD Reduction		98.94		
		% TOC Reduction		87.72		

Comments:

Pilot RBC Data Sheet # B-49

Date 11/27/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	16	-	-	-	17	-
pH	7.6	-	-	-	8.35	-
Alkalinity, mg/l	56	-	-	-	452	-
Dissolved Oxygen, mg/l	8.0	-	-	-	4.3	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	1260	-	-	-	35	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	1238	-	-	-	178	-
BOD, mg/l	1349	-	-	-	194	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	85.62
% BOD Reduction	85.6
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet #B-50

Date 11/28/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	17.5	-	-	-	18	-
pH	4.6	-	-	-	8.4	-
Alkalinity, mg/l	0	-	-	-	364	-
Dissolved Oxygen, mg/l	8.2	-	-	-	6.7	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	490	-	-	-	15	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	3906	-	-	-	137	-
BOD, mg/l	3696	-	-	-	783	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	96.49
% BOD Reduction	78.81
% TOC Reduction	-

Comments: Problems with pH controller on influent.

Pilot RBC Data Sheet #B-51

Date 11/29/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	13	-	-	-	16.5	-
pH	7.2	-	-	-	5.2	-
Alkalinity, mg/l	106	-	-	-	34	-
Dissolved Oxygen, mg/l	10.4	-	-	-	6.5	-
Nitrate/Nitrite, mg/l	-	-	-	-	3	-
Ammonia, mg/l	1260	-	-	-	130	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	3068	-	-	-	1307	-
BOD, mg/l	2901	-	-	-	675	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	57.40
% BOD Reduction	76.73
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet # B-52

Date 11/30/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	9	-	-	-	14	-
pH	6.2	-	-	-	3.8	-
Alkalinity, mg/l	92	-	-	-	0	-
Dissolved Oxygen, mg/l	11.3	-	-	-	8.9	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	1080	-	-	-	300	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2768	-	-	-	1255	-
BOD, mg/l	2234	-	-	-	844	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	54.66
% BOD Reduction	62.22
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet # B-53

Date 12/4/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	17	18	-	-	-	-
pH	7.7	6.4	7.4	7.6	7.7	7.1
Alkalinity, mg/l	88	44	100	134	132	190
Dissolved Oxygen, mg/l	7.2	6.8	7.7	6.9	9.0	-
Nitrate/Nitrite, mg/l	-	-	-	-	2	-
Ammonia, mg/l	660	-	-	-	27.5	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2392	-	-	-	126	-
BOD, mg/l	-	-	-	-	-	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		94.73		
		% BOD Reduction		-		
		% TOC Reduction		-		

Comments:

Pilot RBC Data Sheet # B-54

Date 12/5/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	17.5	18.5	-	-	-	-
pH	11.6	-	-	-	8.4	-
Alkalinity, mg/l	416	-	-	-	196	-
Dissolved Oxygen, mg/l	7.5	-	-	-	9.5	-
Nitrate/Nitrite, mg/l	-	-	-	-	4	-
Ammonia, mg/l	600	-	-	-	15	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2440	-	-	-	288	-
BOD, mg/l	1786	-	-	-	58	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	88.2
% BOD Reduction	96.75
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet #B-55

Date 12/6/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	-	-	-	-	-	-
pH	8.2	-	-	-	8.1	-
Alkalinity, mg/l	98	-	-	-	202	-
Dissolved Oxygen, mg/l	6.9	-	-	-	9.5	-
Nitrate/Nitrite, mg/l	-	-	-	-	4	-
Ammonia, mg/l	840	-	-	-	14	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2462	-	-	-	273	-
BOD, mg/l	1500	-	-	-	67	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	88.91
% BOD Reduction	95.53
% TOC Reduction	-

Comments:

Pilot RBC Data Sheet #B-56

Date 12/10/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	9	16	-	-	-	-
pH	4.6	7.0	7.5	7.7	8.1	-
Alkalinity, mg/l	0	258	358	348	338	-
Dissolved Oxygen, mg/l	13.2	0.35	0.75	1.0	8.5	-
Nitrate/Nitrite, mg/l	-	-	-	-	-	-
Ammonia, mg/l	156	40	-	-	9	-
Formaldehyde, mg/l	-	-	-	-	-	-
Total Solids, mg/l	-	-	-	-	-	-
Total Suspended Solids, mg/l	-	-	-	-	-	-
Total Volatile Solids, mg/l	-	-	-	-	-	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	4710	1313	-	-	340	-
BOD, mg/l	3583	790	-	-	40.7	-
TOC, mg/l	-	-	-	-	-	-

% COD Reduction	92.78
% BOD Reduction	95.53
% TOC Reduction	-

Comments: Problems with pH controller on influent.

Pilot RBC Data Sheet # B-57

Date 12/11/79

Influent Flow Rate 220 gpd
6 rpm

Analyses	Influent	Chamber 1	Chamber 2	Chamber 3	Chamber 4	Carbon Effluent
Temperature, °C	13	17.5	-	-	16.5	-
pH	11.65	7.15	8.3	8.75	8.65	-
Alkalinity, mg/l	548	448	932	1188	1162	-
Dissolved Oxygen, mg/l	10.3	0.25	0.9	6.35	8.0	-
Nitrate/Nitrite, mg/l	1.8	1.2	0.8	1.0	1.2	-
Ammonia, mg/l	1610	50	32.5	16.5	15	-
Formaldehyde, mg/l	1220	455	125	28	33	-
Total Solids, mg/l	2335	-	-	-	1688	-
Total Suspended Solids, mg/l	-	859	274	134	76	-
Total Volatile Solids, mg/l	681	-	-	-	190	-
TNT, mg/l	-	-	-	-	-	-
RDX, mg/l	-	-	-	-	-	-
HMX, mg/l	-	-	-	-	-	-
COD, mg/l	2290	960	224	253	229	-
BOD, mg/l	2036	262	116	50	41	-
TOC, mg/l	-	-	-	-	-	-
		% COD Reduction		90.00		
		% BOD Reduction		97.99		
		% TOC Reduction		-		

Comments: Problems with pH controller on influent.

DISTRIBUTION LIST FOR ARCSL-CR-80028

Names	Copies
Commander/Director	
Chemical Systems Laboratory, ARRADCOM	
ATTN: DRDAR-CLT	1
ATTN: DRDAR-CLN-T	1
ATTN: DRDAR-CLJ-R	3
ATTN: DRDAR-CLJ-L	3
Aberdeen Proving Ground, MD 21010	
Commander	
US Army Environmental Hygiene Agency	
ATTN: HSE-E	1
ATTN: HSE-EW-S	1
Aberdeen Proving Ground, MD 21010	
Commander	
US Army Toxic and Hazardous Materials Agency	
ATTN: DRCPM-DR	1
Aberdeen Proving Ground, MD 21010	
US Army Materiel Systems Analysis Activity	
ATTN: DRXSY-MP	1
ATTN: DRXSY-T (Mr. Kaste)	1
Aberdeen Proving Ground, MD 21005	
Commander	
US Army Armament Research & Development Command	
ATTN: DRDAR-CG	1
ATTN: DRDAR-LC	1
ATTN: DRDAR-LCM	1
ATTN: DRDAR-LCM-SA	5
ATTN: DRDAR-TSS	5
Dover, NJ 07801	
Commander	
Munitions Production Base Modernization Agency	
ARRCOM	
ATTN: SARPM-PBM-EE	1
ATTN: SARPM-PBM-EP	1
ATTN: SARPM-PBM-EC	1
Dover, NJ 07801	
Commander	
US Army Materiel Development and Readiness Command	
ATTN: DRCDE-E	1
ATTN: DRCIS-E	1
ATTN: DRCPA-E	1
ATTN: DRCLDC	1
ATTN: DRCSG	1
ATTN: DRCMT	1
5001 Eisenhower Avenue	
Alexandria, VA 22333	
Commander	
USA DARCOM Installations and Services Activity	
ATTN: DRCIS-RI	1
Rock Island, IL 61299	
Commander	
USA Industrial Base Engineering Activity	
ATTN: DRX-IB-MT	1
Rock Island, IL 61299	
Department of the Army	
Office, Chief of Research,	
Development and Acquisition	
ATTN: DAMA-CSM-P	1
Washington, DC 20310	
Department of the Army	
Office of the Chief of Engineers	
ATTN: DAEN-ZCE	1
ATTN: DAEN-MCZ	1
ATTN: DAEN-RDM	1
Forrestal Building	
Washington, DC 20314	
Commander	
US Army Armament Materiel Readiness Command	
ATTN: DRSAR-IR	1
ATTN: DRSAR-IRC	1
ATTN: DRSAR-ISE	1
ATTN: DRSAR-LC	1
ATTN: DRSAR-PD	1
ATTN: DRSAR-ASF	1
ATTN: DRSAR-LEP-L	1
Rock Island, IL 61299	
Defense Technical Information Center	
ATTN: DTIC-DDA	12
Cameron Station, BLDG 5	
Alexandria, VA 22314	
Commander	
Mobility Equipment R&D Command	
ATTN: DRDME-GS	1
Fort Belvoir, VA 22060	
US Army Construction Engineering	
Research Laboratory	
ATTN: CERL-EN	1
Champaign, IL 61820	
Army Logistics Management Center	1
Environmental Management	
Fort Lee, VA 23801	
Commander	
US Army Natick Research and Development Command	
ATTN: DRDNA-YP	1
Natick, MA 01760	
Commander	
US Army Medical Bioengineering Research and	
Development Laboratory	
ATTN: SGRD-UBG	1
Fort Detrick, Frederick, MD 21701	

DISTRIBUTION LIST FOR ARCSL-CR-80028 (Contd)

Names	Copies
Commanding Officer Naval Weapons Support Center ATTN: Code 3031 Crane, IN 47522	1
Division Engineering US Army Engineer Division, Huntsville ATTN: HNDED-PM P.O. Box 1660, West Station Huntsville, AL 35807	1
Division Engineer US Army Engineer Division, Missouri River ATTN: MRDED-E P.O. Box 103 Downtown Station Omaha, NE 68101	1
Division Engineer US Army Engineer Division, North Atlantic ATTN: NADEN-PM 90 Church Street New York, NY 10007	1
Division Engineer US Army Engineer Division, South Atlantic ATTN: SADEN-M 510 Title Building 30 Pryor Street SW Atlanta, GA 30303	1
Division Engineer US Army Engineer Division, Southwestern ATTN: SWD-ED-MF Main Tower Building 1200 Main Street Dallas, TX 75202	1
Division Engineer US Army Engineer Division, South Pacific ATTN: SPDED-TM 630 Sansome Street, RM 1216 San Francisco, CA 94111	1
District Engineer US Army Engineer District, Kansas City ATTN: MRKED-M 700 Federal Building Kansas City, MO 64106	1
District Engineer US Army Engineer District, Omaha ATTN: MROED-M 6014 USPO & Courthouse 215 North 17th Street Omaha, NE 68102	1
District Engineer US Army Engineer District, Baltimore ATTN: NADEN-MSW P.O. Box 1715 Baltimore, MD 21203	1
District Engineer US Army Engineer District, New York ATTN: NANEN-M 26 Federal Plaza New York, NY 10007	1
District Engineer US Army Engineer District, Norfolk ATTN: NADEN-MT 803 Front Street Norfolk, VA 23510	1
District Engineer US Army Engineer District, Mobile ATTN: SAMEN-MN Mobile, AL 36628	1
District Engineer US Army Engineer District, Savannah ATTN: SASEN-MN P.O. Box 889 Savannah, GA 31402	1
District Engineer US Army Engineer District, Sacramento ATTN: SPKED-M 650 Capital Mall Sacramento, CA 95814	1
District Engineer US Army Engineer District, Fort Worth ATTN: SWFED-ME P.O. Box 17300 Fort Worth, TX 76102	1
Commander Badger Army Ammunition Plant ATTN: SARBA-CR Baraboo, WI 53913	1
Commander Cornhusker Army Ammunition Plant ATTN: SARCO Grand Island, NE 68801	1
Commander Holston Army Ammunition Plant ATTN: SARHO-EN Kingsport, TN 37662	1

DISTRIBUTION LIST FOR ARCSL-CR-80028 (Contd)

Names	Copies
Commander Indiana Army Ammunition Plant ATTN: SARIN-EN Charlestown, IN 47111	1
Commander Iowa Army Ammunition Plant ATTN: SARIO-EN Middletown, IA 52636	1
Commander Joliet Army Ammunition Plant ATTN: SARJO-EN Joliet, IL 69436	1
Commander Kansas Army Ammunition Plant ATTN: SARKA-CE Parsons, KS 67537	1
Commander Lone Star Army Ammunition Plant ATTN: SARLS-EN Texarkana, TX 57701	1
Commander Louisiana Army Ammunition Plant ATTN: SARLA-EN Shreveport, LA 71102	1
Commander Longhorn Army Ammunition Plant ATTN: SARLO-EN Marshall, TX 75670	1
Commander Milan Army Ammunition Plant ATTN: SARMI-EN Milan, TN 38358	1
Commander Newport Army Ammunition Plant ATTN: SARNE-EN Newport, IN 47966	1
Commander Pine Bluff Arsenal ATTN: SARPB-ETD Pine Bluff, AR 71601	1
Commander Radford Army Ammunition Plant ATTN: SARRA-IE Radford, VA 24141	1
Commander Ravenna Army Ammunition Plant ATTN: SARRV Ravenna, OH 44266	1
Commander Sunflower Army Ammunition Plant ATTN: SARSU Lawrence, KS 66044	1
Commander Volunteer Army Ammunition Plant ATTN: SARVO Chattanooga, TN 34701	1